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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625.61 (0 (.493)]

Co-ordination in the operation of main-line railways and light railways,

by R. HENNING,
Inspecteur en chef, adjoint au Directeur de l'Exploitation,
Belgian National Railways Company.

It was under this heading that there appeared on the agenda of the International Railway Congress Association (Cairo Session, 1933) the question of co-ordination of transport by main-line railways and narrow-gauge railways.

Right from the start of his investigation (*), the Reporter made no attempt to conceal his scepticism as regards the possibility of solving the problem.

We extract the following passages from his report :

The question of co-ordination between the large and the secondary railways with which the present report deals is a somewhat delicate one. The heads of organisations who have attempted or are attempting to harmonise the two systems are well aware of the complexity of such a problem.

It would even be allowable to doubt the possibility of reaching any conclusions if it was a question of judging by the fate of the questionnaire which we prepared with a view to drawing up our report. Of the 131 railways to whom this questionnaire was sent, 32 gave us a well studied and informative reply; 13 said they had no answer to give; and the remaining 86 did not consider it any good answering at all.

... It might have seemed valueless to reply to our questionnaire, either because there was co-ordination in certain cases and those concerned did not think it worth while to let us know their methods and the results obtained; or because there was neither possibility or hope of arriving at such co-ordination. But it might also have seemed to some that the very acuteness of the question, the diversity and sometimes even the antagonism of the interests concerned, made the position a rather delicate one, so that it might even be ill-considered to take sides publicly...

The author of this report, Mr. Jacobs, General Manager of the Belgian National Light Railways Company, was more or less justified in giving vent to an almost discouraging scepticism, because, in Belgium, the situation of the standard-gauge and narrow-gauge railways is a very peculiar one.

(*) See *Bulletin of the Railway Congress*, May 1932 issue.

Belgium, with an area of scarcely 30 000 km² (11 600 sq. miles) is covered by a network of 4 900 km. (3 045 miles) of standard-gauge railways and 4 800 km. (2 980 miles) of light (metre-gauge) railways.

There is therefore about one mile of railway track for each 3 square miles of the area.

The light railway lines form an almost complete network which, with a few exceptions, enables both passengers and goods to be carried from one end of the country to the other.

This possibility induced the Belgian National Light Railways Company to increase its receipts by handling long-distance traffic, whereas the idea of the legislators who created this Company was that there should be no complete network of light railways properly speaking. The light railways were to be scattered in between the meshes of the standard-gauge system and feed — at low rates — towards the latter, products from agricultural districts and other industries situated far away from centres served by the standard-gauge railway.

The far-reaching alteration thus undergone by the basic idea which brought the light railways into being was bound to create competition which can unhesitatingly be qualified as paradoxical.

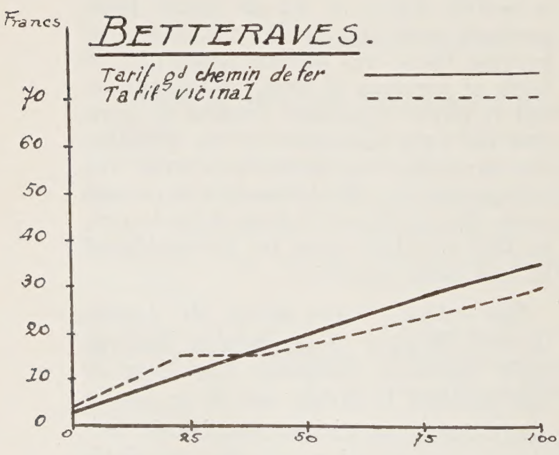
Is it not, indeed, a paradox that two Companies in which the Public Powers have invested large amounts of capital should start a tariff war to the detriment of public finance?

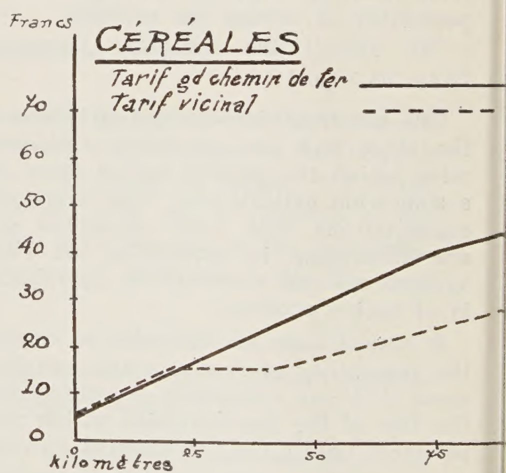
The Managements of the two Systems realised this and by mutual consent sought to apportion the traffic so as to take into account the particular features of each system.

Many attempts were made but none met with real success.

The failures met with by the most seductive attempts were mainly due to absolutely different systems of rates in force on each of the two Railways.

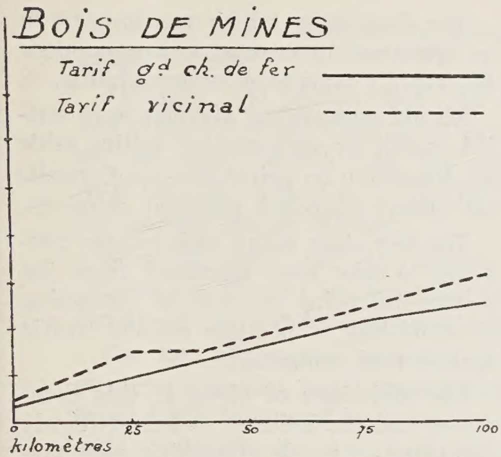
The diagrams below show, for a few classes of goods, the rates in force on standard-gauge and light-railway lines.

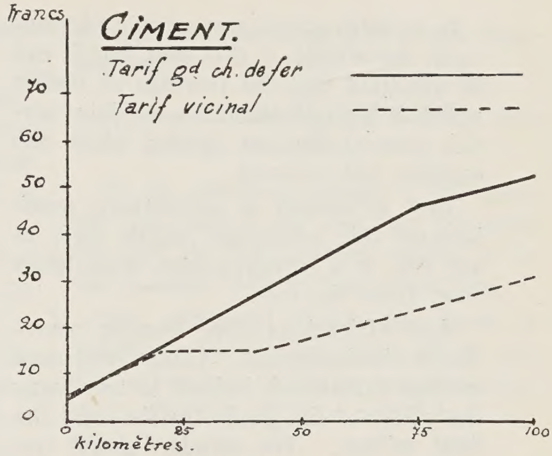




Explanation of French terms :

Betteraves = beetroot. — Céréales = cereals. — Tarif g^d chemin de fer = main-line railway tariff. — Tarif vicinal = light-railway tariff. — Bois de mines = pit props. — Ciment = cement.





These diagrams clearly show the considerable difference that exists between the two tariffs.

One might take into consideration the sharing of traffic by forwarding same by the shortest route, but in order to do that, one would have to apply on the light railway the rates in force on the standard-gauge railway. This solution, the most logical at first sight, had to be abandoned for several reasons, of which we will merely quote two :

1. The rates of a standard railway system are necessarily fairly complicated. They are based on the changing requirements of trade and industry. A light railway need not preoccupy itself with the same considerations, and its staff, disseminated across the country, often composed of temporary hands engaged on the spot, has no opportunity to become familiar with rating principles which are undeniably complex;

2. If the light railways were in all instances to adopt the rating system of the standard-gauge railway, traffic would have a still greater tendency to avoid the mixed route and remain constantly on the light-railway system. As a matter of fact, mixed transport causes a rise in charges at the change-over point, as well as transhipping expenses.

The additional cost resulting from these two causes and the sliding scale of the tariffs would enable the run over the light-railway system to be considerably lengthened without entailing a higher total charge than on a mixed service.

It therefore appeared that a solution could not be obtained from tariff measures.

But road competition became more and more acute and, faced with the danger it aroused to both Systems, a passive attitude could no longer be maintained : it became necessary to combine their efforts and stop competing with one another, in order to resist the attacks of which both of them were beginning to feel the disastrous effects.

The first step they took was to abolish transhipment charges at connecting points. Goods were henceforth transhipped by the carriers and at their expense. The standard-gauge railway bore two thirds of the cost of this, and the light railway one third of same.

It is difficult to pass exact judgment upon the effects of this step, but it can be admitted that the increase in traffic which it brought about for the joint service covered the new burden which the carriers had assumed.

That is already a satisfactory result because this additional traffic had, at any rate to a certain extent, been taken away from the road.

More efficacious steps became, nevertheless, indispensable. Competitive road haulage threatened, indeed, to take away the whole of the goods traffic from the light railway. The standard-gauge system would undoubtedly have also suffered to a certain extent.

The Managements of the two Railway Systems then decided to set up a committee called the « Mixed Committee », and composed of delegates from each of the two Systems.

Its mission was :

(a) to settle, in a spirit of equity and mutual confidence, all controversies which had arisen during the time when the two railways were competing;

(b) to study the effects of all decisions about to be made by one of the Systems and which might, in some way or other, affect the other one;

(c) to try and find means for real co-ordination in the working of the two Systems.

The Committee, which was to come to an agreement in as short a time as possible, rapidly came to an understanding.

All old outstanding disputes were settled, mostly by compromise : setting aside all discussion on principles, the Committee always proposed practical solutions.

The new steps which each railway proposed to take were discussed from the primordial point of view of protecting as efficiently as possible railway traffic against road competition.

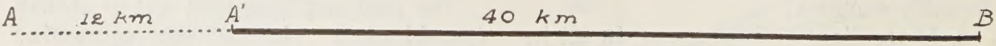
The exchanges of views in this Committee had the indirect — but extremely fortunate — result of making each system understand the requirements of the other, and of allowing discussion to proceed in a perfectly objective way.

There remained to be settled the question of co-ordination properly speaking.

After many investigations, the Committee framed the conclusions which we analyse further on, and which were approved by the proper Authorities of each System :

The light railway retains its own tariffs for all traffic carried solely over its own system.

When it is a question of mixed traffic, the rates of the standard-gauge railway is prolonged — without any additional charge at the connecting point — over the light railway. The following example will make the arrangement clear :



The dispatching station *A* is served by the light railway;

Station *A'* is the connecting point of the light railway with the main-line railway;

B is the destination station of the con-

signment. It is served by the standard-gauge railway.

Formerly, the section *A-A'* (12 km.) was rated according to the tariff in force on the light railway and the section *A'-B* (40 km.) according to the tariff of the standard-gauge railway.

Since 1st April 1937 the section *A-B* (52 km.) is charged for according to the tariffs of the standard-gauge railway.

The loss in receipts accruing to the carriers from this tariff standardization being fairly high, and as it was not possible to foretell the effects of this new rating, the method of unification was slightly amended : a consignment forwarded by the combined service pays for the total route *(A-B)* at the rate in force on the standard-gauge railway, but it has to bear an additional charge of 20 centimes per metric ton and per kilometre run over the light railway system, with a minimum of 20 centimes per consignment.

In the instance mentioned above the consignment sent from *A* to *B* will therefore pay :

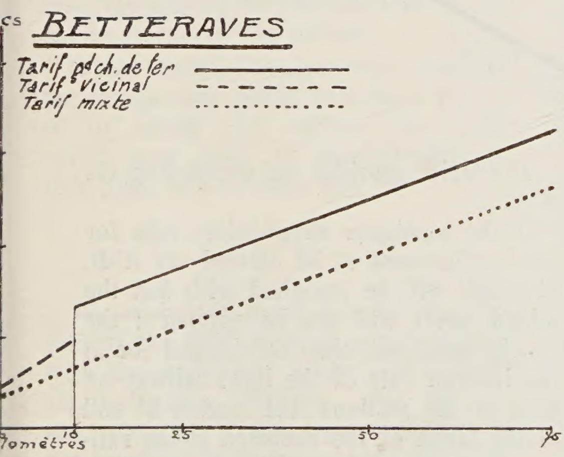
(1) the standard-gauge railway rate for a distance of 52 km.;

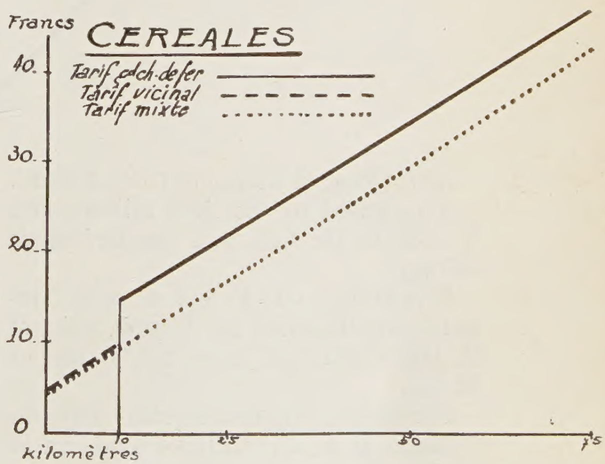
(2) an additional charge of 20 centimes per metric ton and per kilometre run over the light railway system, or in this instance 2.40 fr. per metric ton.

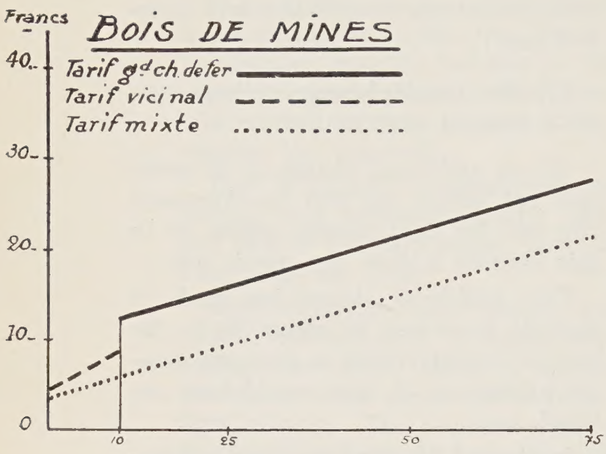
This additional charge has made it possible to reduce by about 30 % the loss in receipts which a pure and simple unification of rates would have entailed.

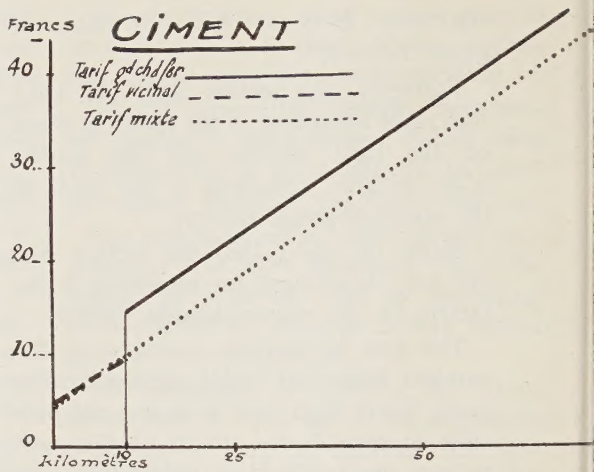
In view of the hope that may be placed in co-ordination, the tariff unification thus amended has been accepted by all rail carriers, viz. The Belgian National Railways Company, the Nord-Belge Lines, the Malines-Terneuzen Company, the Chemin de fer de Chimay, and the Belgian National Light Railways Company.

Unification of rates demanded an agreement as to the routing of the goods.





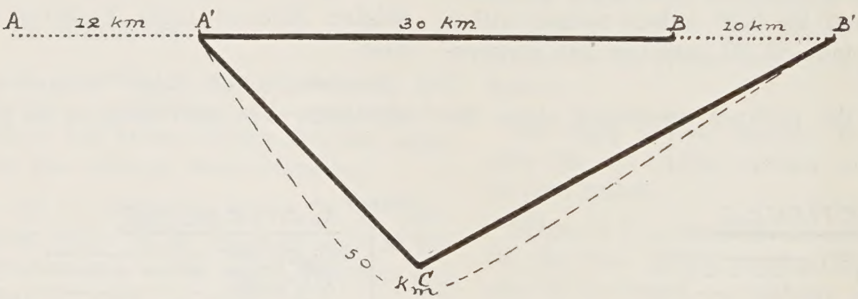




On principle, consignments are planned to follow the shortest route. Two exceptions have, however, been made to this rule, because :

(1) Additional unnecessary transhipments had to be avoided.

The following diagram shows a case in which the routing can include only one, or two transhipments :



It is a case of transport from *A* to *B'*.

A is served by the light railway, and B' both by the light and standard-gauge railways.

Forwarding via *A'* and *B* would require transhipment at *A'* and again at B, but would only mean a total run of 52 km.

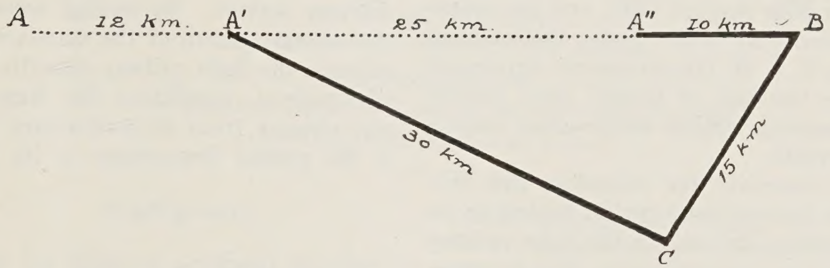
Forwarding via *A'-C* requires only one transfer, at *A'*, but entails a total run of 62 km.

The tariff provides for forwarding via *A'-C*.

If the consignor nevertheless asks for his consignment to be carried via *A'-B*, his wish will be complied with but the mixed tariff will not be applied : the consignment will then be charged for at the interior rate of the light railway on each of the sections *A-A'* and *B-B'* and at the tariff of the standard gauge railway over the section *A'-B*. In addition,

the charges for transhipment at *A'* and *B* will be applied, whereas these expenses are borne by the carriers in the case of consignments at the joint tariff.

(2) The joint tariff must re-establish the light railway in the part it has to play, i.e. ensure transport over short distances.



A consignment from *A*, served by the light railway, is to be sent to *B*. It can be sent via *A'-A"* and via *A'-C*.

The first route means a total run of 47 km., 37 km. being over the light railway's system. The second route means a total run of 57 km., only 12 km. of which are over the light railway's lines.

On the joint service, the change-over must necessarily take place at *A'*, but in this case again the consignor can have recourse to split tariffs if it be to his advantage. It is understood that, in this case, the cost of transhipment at *A"* will not be borne by the railway.

It may be said that, generally speaking, the change-over points have been arranged by taking into account the routes which were used for consignments before joint tariffs came into use.

* * *

We explained above that the organisation of the light railways could not cope with the complexity of the tariffs of the standard-gauge railways. For this reason, stations of the light railways are not burdened with the making out of the charges. It is the connecting station which makes out the waybill and inscribes the total charge to be paid. The light railway station restricts itself to making out a waybill to or from the connecting station and shows the sum it would have collected if joint tariffs had not existed. This document will enable it to be ascertained, when the time comes, to what extent the light-railway system has participated in the sacrifice which joint tarification imposes upon carriers.

When a sufficiently long experience will have shown the factors of the proportion in which the sacrifice varies, these statistics will be abandoned and the participation of the light railway will be fixed by contract.

Mixed tarification has been extended to international traffic from Belgium to places for which there is no through tariff.

The consignor, whose factory is served by the light railway, indicates as the despatching station the junction station with the standard-gauge railway. The latter makes out the waybill and mentions on it the charge as far as the frontier station, taking into account the dis-

tance calculated from the actual place of despatch.

From a legal point of view, obviously the run over the light railway's lines continues to be governed by the Belgian law of the 25th August 1891, and the transportation only comes under the auspices of the C. I. M. (International Agreement on the Carriage of Goods) after leaving the junction station which alone stamps the waybill.

The necessity for extending this system to international traffic having as its destination stations on the light railway system has not yet arisen. The question is, however, being studied.

* * *

In order to make co-ordination still more efficient, stations on the standard-gauge railway have placed at the disposal of the light railway their cartage (collection and delivery) services.

A consignment arriving at a station of the light railway situated in a locality where the standard-gauge railway has a cartage service can therefore be delivered at the consignee's door. Equally, a consignment to be carried solely by the light railway can be taken from the domicile of the consignor to the light-railway station.

In most instances, goods traffic of the light railway is insufficient for the light railway to organise itself a collection and delivery service. By having recourse to the cartage system of the standard-gauge railway, the light railway benefits by the advantageous conditions the larger railway obtains from its contractors, thanks to the greater importance of its traffic.

* * *

Co-ordination also exists as regards passenger traffic.

On given routes, there have been created season tickets available over a given section of the standard-gauge railway and another section of the light railway.

On the other hand, when a light railway station shows traffic of some importance, the principal stations on the standard-gauge railway issue tickets to the light-railway station in question.

Co-ordination is thus created to the full extent to which it may be advantageous to the public and where it may counteract any efforts made by competitors.

[625. 25 (.44)]

Light metal suburban coaches designed by the French Est Railway,

by Messrs. PONCET,
Ingénieur en chef du Matériel et de la Traction,
and FORESTIER,
Chef adjoint du Service des Études du Matériel et de la Traction.

(Revue Générale des Chemins de fer.)

FOREWORD.

The Est Railway Company decided in 1929, for reasons of safety, to replace wooden-bodied double-decker suburban vehicles by metal ones.

A first series of 120 coaches was put into service in 1932. These coaches, constructed on the « tubular » principle, have given entire satisfaction from the point of view of both comfort and maintenance, but the need for producing very strong stock at a moderate cost led to relatively high dead weights.

The dead weight, per seat available, reached 226 kgr. (498.2 lb.) for a second-class coach (tare 41.5 t. = 40.8 Engl. tons), and 220 kgr. (485 lb.) for a third-class coach (tare 43 t. = 42.3 Engl. tons). The sets of ten coaches used at first weighed 472 t. (464 Engl. tons) empty.

To haul this metal stock it was therefore necessary to design and build locomotives with four coupled pairs of wheels (series 141 700), more powerful than the 4 400 engines which had previously been sufficient for the suburban services.

In 1934, when considering the question of electrification, the Company was led to compare the various possible solutions for the suburban services in order to find which would be the most economical. After a careful investigation, in the case of the suburban lines leaving the Paris-Est station, it was decided to retain steam traction and to build new metal carriages of a weight low enough to avoid the heavy expenditure necessary for new locomotives.

Tractive trials carried out at that time shewed that the class 4 400 engines used with the wooden-bodied double-decker sets would be able to haul trains of nine metal carriages (the composition adopted in 1934, following the suppression of first class), at the same speeds, provided that the tare was at least 6 tons less than that of the first metal coaches.

In these circumstances, the problem was to design a suburban coach, the weight of which would not exceed 35 or 36 t. (34.4 to 35.4 Engl. tons), the following conditions, however, being imposed :

— strength and comfort at least equal to that of the earlier coaches;

— retention, for reasons of homogeneity, of the general type of construction previously employed;

— limitation of the additional cost, due to lightening and various improvements, to a total which, according to the established balance, would not exceed 50 000 francs per vehicle.

The coaches ordered by the Est Company, following this investigation, conformed entirely to the conditions laid down. The tare, in particular, will be clearly below the fixed limit, since it is hoped that it will not exceed 32 t. (31.5 Engl. tons).

We propose, in this article, to give some details of the method of construc-

tion, and of the means adopted for obtaining a very important weight reduction with a minimum of expense.

General principles of the new design.

As has been pointed out above, the Company has retained the general method of construction followed for the first vehicles and has sought, in particular, to utilise only those materials and methods of construction which are compatible with French industrial and economic interests, so that there would be extensive competition for the work.

It is above all by a rational use of these materials and methods of construction that the Railway was able, as we shall see later, to obtain the desired lightening. However, a preliminary investigation was carried out in connection with general modifications in the arrangement, likely to give the same result, modifications which concerned the number and size of the standing platforms as well as the size of the exits.

Its investigations have led the Est Railway to believe it possible to dispense with the use of three platforms in the third-class coaches (an arrangement which was adopted in the earlier vehicles in order to increase the capacity at rush hours and to accelerate the entry and exit of passengers).

On the other hand, the wide steps provided in the first vehicles so as to retain the easy exit facilities were retained.

The surface and dimensions of the platforms have been determined with due regard for the regulations imposed by the Authorities on the proportion of passengers seated and standing, and the space available for the latter.

Diagrams of the early vehicles, types B^9 and C^8, as well as of the new coaches, types AB^9 and C^{10}, will be found in figures 1, 2, 3, and 4.

The orders now being executed in the works of four contractors include, in addition, composite first/second and third-class coaches, series ABsC, and of third class-brake compartment coaches, series CD. A total of 90 coaches for the 1936 programme of construction is in hand.

Description of the construction.

I. — Tubular framework of the « frame-body ».

The essential characteristic of the design of the « Est » carriages rests, in general, in the tubular construction of the frame-body unit, which is an essential condition for obtaining maximum utilisation of the material for resistance to normal vertical stresses, as well as to accidental end forces as will be gathered from the diagram, figure 5, showing the principle of the design.

The adaptation of the tubular form to the new suburban coaches of the Est Company is outlined in the perspective view, figure 6. The characteristic features of this type of construction may be summed up as follows :

(*a*) Underframe encased in the bodywork and surmounted by plates, forming the stretched part of the girder under flexure.

These plates also form the bond between, and the general bracing for, the buffing and drawgear members, the solebars and cross bearers, all these elements being of pressed steel closed sections with a high moment of inertia.

It will be noticed that the constitution of the pressed steel underframe is particularly remarkable for its cohesion and by the elimination of all heavy parts, either in sections or steel castings (fig. 7).

(*b*) Roof designed to absorb all the compression forces from the girder under flexure.

The ends and sides of the coaches in consequence merely act as joints between the lower stretched part (under-

Fig. 1. — Diagram of B9 type coach, 1930 design.

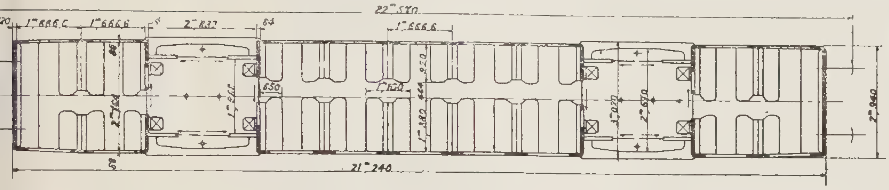


Fig. 2. — Diagram AB9 type coach, 1936 design.

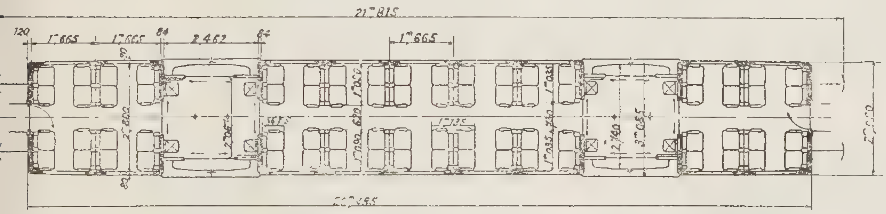


Fig. 3. — Diagram of C8 type coach, 1930 design.

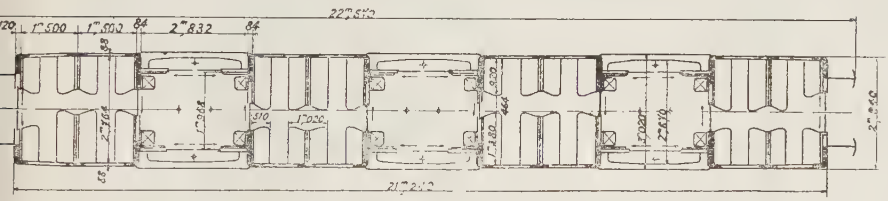
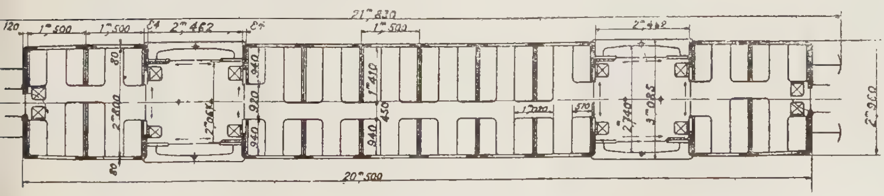
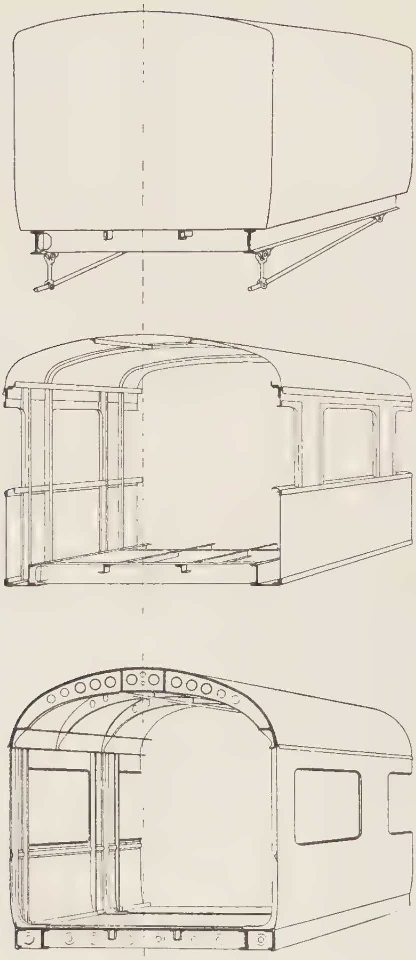


Fig. 4. — Diagram of C10 coach, 1936 design.



Passenger carrying capacity.		Tare, Metric (*English*) tons.
Seated.	Standing.	
92	91	41.05 (*40.85*)
72	108	32 (*31.5*)
78	117	43 (*42.3*)
94	109	32 (*31.5*)



WOOD-BODIED COACH.

Bending and compression strength localised in the strutted steel frame. (Shallow girder having a very small moment of inertia.)

SEMI-TUBULAR METAL COACH.

Bending and compression strength localised almost entirely in the underframe and sides. (Moment of inertia limited to that of these parts.)

TUBULAR METAL COACH.

Bending and compression stresses taken by the whole of the underframe strengthened by plates, the sides and the roof, using the maximum value of the moment of inertia resulting from the fully tubular construction, the nearest approach to the ideal shape of a tube of circular section.

Fig. 5. — Diagrams of the various types of girders. — Principles of design.

frame) and the upper compressed part (roof).

The result is that the moment of inertia for the section is at a maximum and it becomes possible, for equal strength, to markedly decrease the mass of metal used.

The aspect of the constructional problem is thus changed, and the whole of the coach can be conceived as a properly tubular underframe-body girder, utilising the casing plates directly for resistance, without the heavy framing inspired by the old wooden construction.

To perfect this design, it is sufficient, to prevent possible local warping by a system of interior strengthening of the tube, easily obtained by using a few

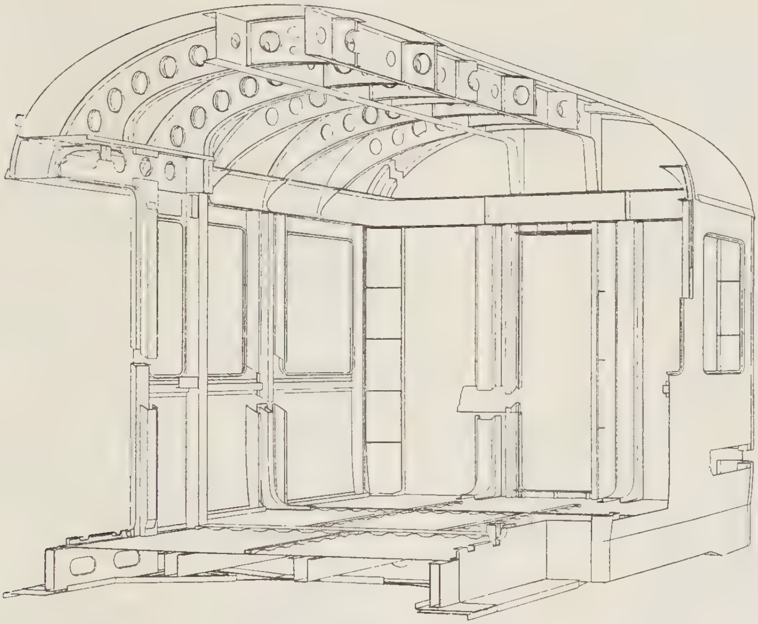


Fig. 6. — Perspective view of the tubular girder.

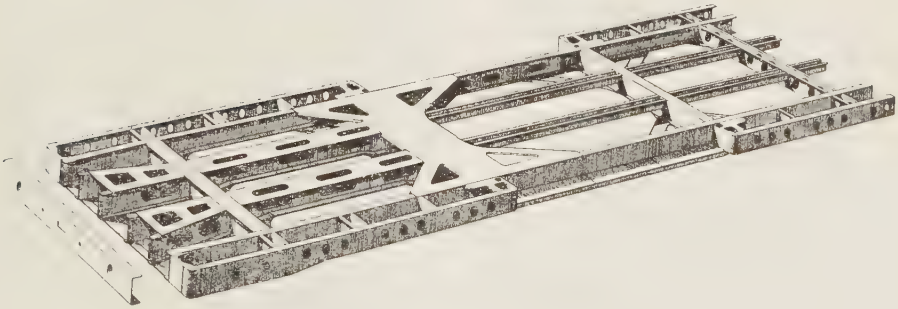


Fig. 7. — Perspective view of the frame ends (with the upper plates removed), showing the pressed steel box-shaped buffing and drawgear members.

light pressed sections, closed as far as possible.

(*c*) Powerful joints obtained by extended overlapping and direct welding, without the introduction of intermediate assembly parts, between the frame plates, walls and roof (fig. 8).

These joints, whose extremely high resistance is in direct contrast to the unreliability under shock of the rivetted joints used in other forms of metal construction, provide this stock with a higher coefficient of safety.

(*d*) Combination of pressings and welding to give continuity of the plates, without projections or apparent joints.

This type of construction, known as shouldered joints, has very appreciable advantages : elimination of causes of corrosion, easier to paint, and better be-

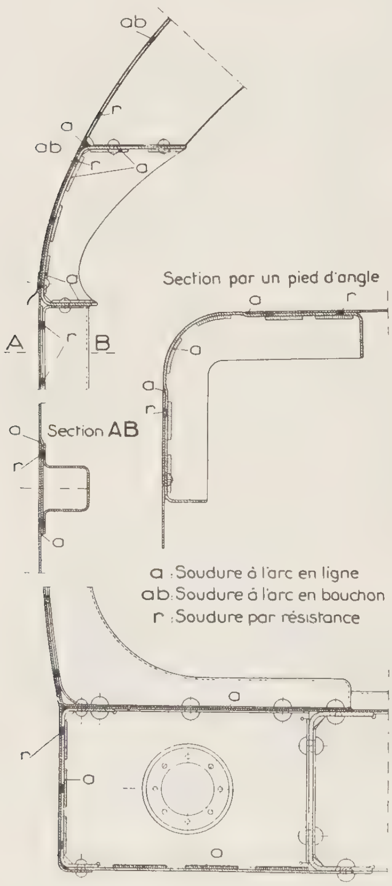


Fig. 8. — Characteristic examples of welded joints.

Explanation :

Section par un pied d'angle = cross section of a corner pillar.
a Fillet weld (arc welding).
ab Plug weld (arc welding).
r Resistance weld.

haviour of the paint in service, easier to wash by machine, reduction of air resistance, and improved appearance.

The problem of the best shapes for obtaining the maximum strength being thus solved, a second step could be considered in the search for weight saving, the use of high-tensile steels.

Having avoided the danger of warping by the extended use of pressings, and the appropriate shape of these members (which will be readily seen from an examination of figures 6, 7 and 8), it became possible further to decrease the thickness, and hence the mass, of metal used, by increasing its mechanical properties.

In this way the American « Budd » method of construction, has made it possible, with an 18 % chrome and 8 % nickel steel (giving a breaking strength of about 120 kgr./mm² = 76 Engl. tons per sq. in.) to reduce the thickness of the plates to a few tenths of a millimetre.

It has not been thought necessary, however, to go so far in solving the present problem, which is to work trains of a given composition with existing locomotives, and it was decided to use a much cheaper steel, of a kind normally manufactured in France. Consequently we have used semi-hard steel which costs eight times less than the 18-8 high-tensile nickel-chrome steel, and which, with an average tensile strength of 60 kgr. (38 Engl. tons per sq. in.) only, has yet permitted a weight saving of *3 100 kgr. (6 834 lb.)* in the body frame, without requiring our builders to make any modification whatever in their constructional methods or in their plant.

The additional cost, compared with the price of ordinary steel, Class AO, used for the 1930 type coaches, taking into account both the decrease in weight and the increased price of semi-hard steel, is only about 9 000 francs or 2.7 % of the total cost.

We considered, therefore, that with the various other means of lightening described later, this first step had sufficiently contributed to the solution of

the problem set, and this under conditions which were commercially sound, and acceptable.

The following table sets out a comparison of the principal characteristics of the plates used in 1930 and in 1936 :

	1930. — « AO » steel. —	*1936.* — Semi-hard steel. —
Breaking strength	35 kgr./mm² (22.2 Engl. tons/sq. in.)	58/65 kgr./mm² (36.8 to 41.3 Engl. tons/sq. in.)
Elastic limit	20 kgr./mm² (12.7 Engl. tons/sq. in.)	40/50 kgr./mm² (25.4 to 31.7 Engl. tons/sq. in.)
Elongation	28 %	18 %
Cross resilience	5 kgrm. (36 ft./lb.).	6 kgrm. (43.4 ft./lb.) (minimum).

Box-girders (caissons) and elastic draw and buffing gear.

The lightening of the frame-body presented a very delicate problem with regard to the local resistance at the ends.

As is known railway stock is subjected to extremely high stresses in case of accident, or even during the shunting of the trains, the speed of which has constantly increased during late years.

It seems opportune to recall that these peculiar circumstances have severely handicapped us, and this aspect of the question appears to be often lost sight of when comparing metal construction for railway vehicles with that for other methods of transport; doubtless, if we had to take into consideration only the tractive effort needed for hauling the train, or the normal exchanges of movement between vehicles of a train in motion, or when starting or stopping, we could design a far lighter underframe.

To make the best possible use of these unfavourable circumstances, we think the best solution again consists in the use of box-girders made of steel pressings.

Figure 7 gives a perspective view of these box-girders extending from the headstock to the bogie bolster, and capable of absorbing, with an elastic deformation of about 6 mm. (1/4 inch) a mean force of 1 500 t. (1 476 Engl. t.) providing an elastic work of 4 500 kgrm. (32 540 ft./lb.).

Such an underframe end forms a true shock-absorber, and adds, to the normal efficacy of the springs, the inertia effect resulting from its mass, so that accidental momentary stresses are almost completely absorbed within this important zone. Any residual forces are spread amongst the framework of the coach by means of the large gusset-plate joints to the bolster beam.

The caissons themselves are protected by helical buffer springs, capable of a force, fully compressed, of 6 300 kgr. (13 890 lb.) with a working efficiency of 480 kgrm. (3 470 ft./lb.) (per buffer), and by armoured rubber shock-absorbers, each capable of a force of 100 000 kgr. (220 460 lb.), with an efficiency of 400 kgrm. (2 890 ft./lb.).

Experience has shewn the necessity of preventing the localisation of destructive stresses by rubber shock-absorbers mounted on the periphery of the holes provided in the headstocks for the buffer plungers, and we think it of interest to point out the strengthening, by a welded tube, adopted at this point of lower resistance (fig. 9).

It will be noticed from figure 7 that there is also a close assembly between the buffing caissons and drawgear caissons.

The buffers and the supporting blocks (dead buffers) have been lightened, as also have the buffer springs (helical spring replacing the usual heavy laminated spring).

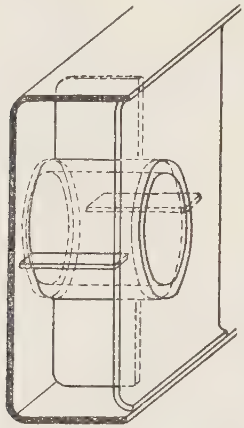


Fig. 9. — Buffer strengthening member.

The drawbar hook of the standard type now used on our rolling stock has been retained. Draw-springs in armoured rubber are fitted, capable of an effort of 100 000 kgr. (220 460 lb.) when fully compressed, with an efficiency of 1 200 kgrm. (8 680 ft./lb.).

II. — *Bogies* (fig. 10).

Improvements in the construction and suspension of the Est Railway Company's bogies have been described in our article in the January, 1930, number of the *Revue Générale des Chemins de Fer*.

The particular arrangement for bracing these bogies, known as *centre-ring bogies* had allowed the retention, up to the present, of the polybloc type of construction, which is easier to tender out, and also more economical than the monobloc type, to which we have, however, returned in the present vehicles for weight saving reasons.

The recognised rigidity of the frame has brought out the possibility of « standardising », in a very exact way, all running and suspension gear moving relatively to one another, and this has resulted in further appreciable progress in the reduction of play, parasitic movements, wear and tear, as well as in improved running and comfort. The suspension gear has, in fact, shewn itself as one of the best actually in use.

Under these circumstances it would have been undesirable to modify this type of bogie if, on the one hand it had not been so important, in order to lighten the vehicles as a whole, to strictly reduce the weight of all parts without exception, and also, on the other hand, if the reduction in the suspended weight itself had not justified an investigation into the additional means of damping out vibrations.

Weight reduction.

1. *Unsprung weight.* — Our principal efforts were directed towards the reduction of the unsprung weight, i.e. axles, axleboxes, wheels and equalisers.

(*a*) *Axles.* — In order not to sacrifice the advantages of the standard axle, they have been merely lightened by hollowing out a channel 70 mm. (2 3/4 in.) in diameter around its neutral fibre, this channel being closed at the ends by plugs with turning-centre holes (fig. 11). The weight saved is 275 kgr. (606 lb.) per vehicle.

(*b*) *Axleboxes.* — The retention of a standard axle has also permitted that of standard interior axlebox fittings. The Est « M » type axlebox, derived from the standard U 2 A type, by a simple adaptation of the fitting of the equalisers, has been retained. It has, however, been lightened by reducing the thickness of the walls (96 kgr. = 212 lb. of weight saved per vehicle).

Roller-bearing axleboxes have been rejected on account of the weight increase of 480 kgr. (1 058 lb.) per vehicle

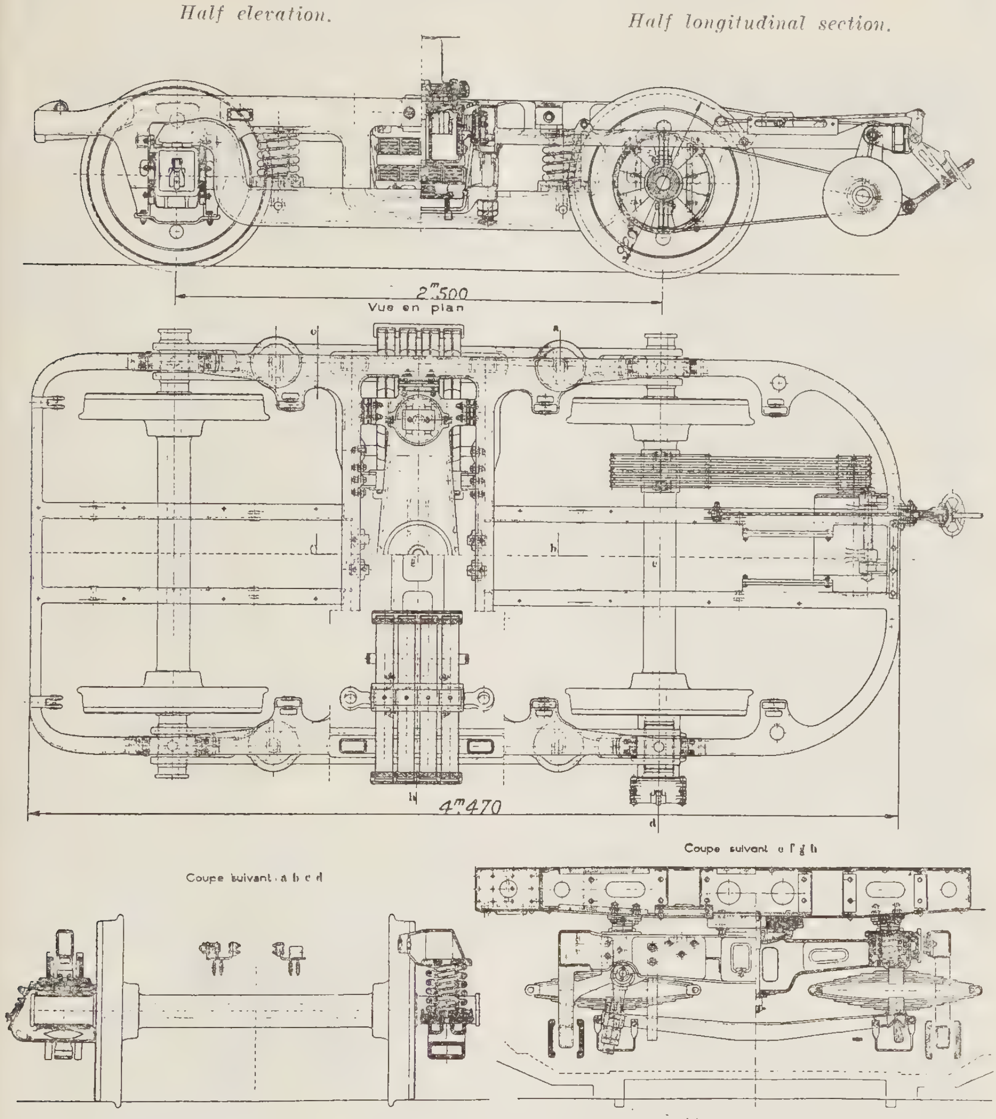


Fig. 10. — Diagram of lightened monobloc bogie.

which they involve, without sufficient economical advantages for suburban services.

(*c*) *Wheels.* — We considered the possibility of designing a monobloc wheel of special steel, which would have given a weight saving of 1 400 kgr. (3 086 lb.) per coach, but this had to be given up, as the maintenance costs would have been very high.

Consequently only the body of the

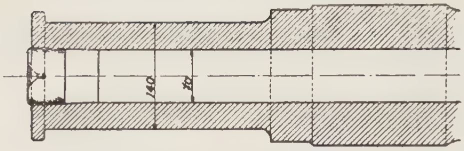


Fig. 11. — Hollow axle.

wheel has been lightened, the standardised shrunk-on 75-mm. (2 15/16 in.) tyre being retained.

The wheel body is of the radial corrugated type, in cast steel, giving a weight saving of 320 kgr. (705 lb.) per coach.

(*d*) *Equalisers.* — These were subjected to a very close investigation which has shown the impossibility of using economically plates or forgings of high-tensile steels [elastic limit up to 90 or 100 kgr. (57 to 63.5 Engl. tons/sq. in.)]. The price of these steels is still prohibitive and the possible weight saving, strictly limited by the flexure of these parts, is too small to justify their use in this particular case.

We then realised that interesting results could be obtained by taking advantage of the ease with which a monobloc and caisson form could be given to ES cast steel of 50-kgr. (31.7 Engl. tons/sq. in.) tensile strength. We have thus been able to combine in one single piece the two equalisers usually assembled with intermediate pieces.

The elastic limit of this part is five to six times higher than the normal load of 10 500 kgr. (23 450 lb.) distributed over the two helical spring sockets. A specimen tested was not broken under a load of 105 t. (103.3 Engl. tons) which was the power limit of the testing machine. The safety factor is therefore very high, though the lightening obtained is 315 kgr. (694 lb.) per coach.

Finally, the bolster beam has been lightened by the use of ES cast steel and by the application of the tubular form of construction to its casting. The weight saving is 90 kgr. (198.4 lb.) per coach.

2. *Spring-borne weight.* — Of the total weight of a present-day bogie (6 340 kgr. = 13 480 lb.) the frame represents only 1 210 kgr. (2 667 lb.). It appeared, however, interesting to profit by the latest improvements in foundry practice further to lighten this part. By reducing the thickness to the possible minimum of 10/12 mm. (3/8 in. to 1/2 in.), by simplifying and reducing as much as possible the size of sections by returning to the monobloc idea, and by using ES cast steel of 50-kgr./mm² (31.7 Engl. tons/sq. in.) tensile, it has been possible to reduce the weight of the bogie frame to 935 kgr. (2 061 lb.) (representing a saving of 500 kgr. = 1 100 lb. per coach), even though its length was considerably increased to allow it to accommodate, if need be, a 3-kw. dynamo.

No better result would have been obtained by using a pressed and welded monobloc frame, made of special sheet steel, and this was likely to be more expensive.

Various other weight savings have been obtained, notably in the brake gear, by a judicious use of ES cast steel, which is so suitable for manufacturing rational sections and parts as regards strength, such as blocks holders, brake triangles and brake levers — saving 212 kgr. (467 lb.) per vehicle.

Careful comparisons showed us, moreover, that nothing would have been gained by grouping on the bogie the brake application equipment : cylinders, reservoir, triple valve and automatic adjusters. We would, on the contrary, have introduced some undesirable complications, doubled the number of parts required, and also made the use of hose pipes a necessity.

We also rejected the use of costly light-metal cylinders, which would have required cast iron sleeves, and steel or

cast iron connections screwed into the solid.

Altogether, the weight of the new bogie will be 5 340 kgr. (11 770 lb.), or 910 kgr. (2 006 lb.) less than the present bogie. Bearing in mind that the frame of the new bogie is equipped to carry the lighting dynamo, it appears that the weight saving, increased by the fact that the means for suspending the dynamo under the body are dispensed with, is 1 935 kgr. (4 265 lb.) per coach.

It should be noted that the general strength of the bogie and its standard axles is sufficient to allow it to carry main-lines carriages of the current type, not lightened, and weighing on the average 47 t. (46.25 Engl. tons) [which may be as much as 49 t. (48.2 Engl. tons) when electrically heated].

Improvements in the suspension gear; prevention of noise and vibrations.

The general arrangement of the bogie helical suspension springs and elliptic body bearing springs on our present stock, which has proved quite satisfactory, has been retained by simply adapting the flexibility of the springs to the new weight of the lightened vehicles.

Various improvements have, however, been made in the assembly :

— The position of the helical springs on the equalisers and on the bogie frame has been brought nearer to the axles, in order to increase longitudinal stability, particularly when braking.

— The centre pin has been relieved of 30 % of its load (when the coach is half-loaded), by the permanent incorporation of flexible transoms controlled by helical springs housed on the two ends of the bolster beam, each absorbing 15 % of this load.

It is hoped that this will improve the working of the spherical centre pivot, the inherent rotation difficulties of which, due to irregularities as regards sphericity, and expulsion of the lubricant, are well-known.

This arrangement is also a simple and effective means of damping out the crawling motion of the bogies, and should thus decrease lateral perturbation in running, and increase the comfort.

— Rubber pads, strengthened inside by means of steel plate, have been placed in two successive stages on the bogie centre pin, and under the helical suspension springs.

Simple rubber leaves have been introduced into the assembly of the transoms, lateral guides and bolster beam stops.

These arrangements will have the effect of absorbing short-period vibrations, and noises transmitted from the track to the body by the vertical and horizontal components of the periodic forces resulting from the shock of the unsprung masses particularly when passing over rail joints.

It should be noticed that we always use *thin* layers of rubber, with a deflection under load limited to 1.5 to 2 mm. (0.059 to 0.078 inch), in order to avoid the drawback of setting up appreciable amplitudes in case of specific resonance of this rubber at certain speeds; thanks to the special composition of the material, they are damped out.

The low unit pressure allowed, less than, or at the most equal to, 12 kgr./cm^2 (170.7 lb. per sq. in.), is moreover the best guarantee of long life for the suspension pads.

Mounting of the lighting dynamo on the bogie.

Whilst the present 1 500-watt dynamo, sufficient for suburban vehicles, has been retained, the bogie has been designed to take a 3-kw. dynamo which can be used on main-line coaches.

In either cases, the suspension will be « Oscillit » damping rings, and the driving by trapezoidal belts, four-ply in the first case and six-ply in the second. The tension in these belts is controlled by a new type of tightener arti-

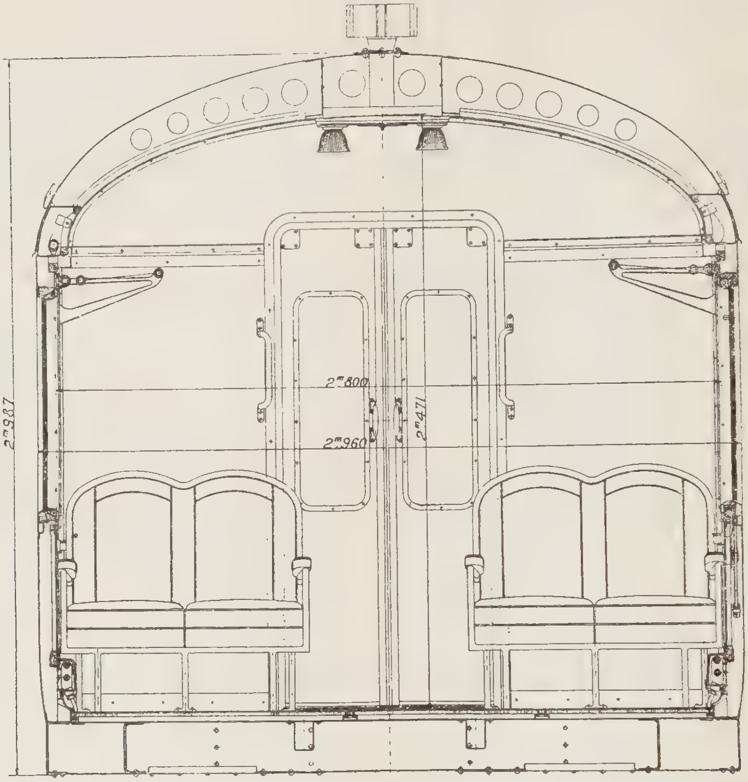


Fig. 12. — Cross section of a first/second-class compartment.

culated on the end member of the bogie frame and which protects it from the undesirable torsional forces experienced with the ordinary arrangements used up to the present.

III. — *Interior fitting out of the body. Light metals* (fig. 12).

Floor. — Even when our first metal rolling stock was built we considered that the tubular girder with frame plates would permit the retention of all the advantages of the wooden floor formerly used — with intermediate air layer, and « molleton » (soft cotton fabric) — and whilst being most economical to make and maintain would provide a far better heat and sound insulation than that of a floor of corrugated sheet iron and magnesium cement.

In the new lightened carriages we have further simplified this floor, reducing its thickness and weight (12.2 kgr./cm^2 = 1.73 lb. per sq. ft. including all supports) by making it of seven-ply wood panels 15 mm. (5/8 in.) thick, placed on pressed metal joists, welded to the frame strengthening plates.

Lining out of the side walls, partitions and roof. — Sliding doors. — Fittings.

The incomparable neatness and ease of maintenance offered by glazed plate led us to use this type of material for the walls, seat backs and partitions in the original suburban vehicles (these plates extended from the floor to a raised waist rail).

However, the furnace treatment of this lining did not permit of the use of thin,

light sheets, and the method has been abandoned in the new vehicles, in favour of 14/10 mm. (9/16 in.-3/8 in.) Almasilium alloy sheets.

Furthermore, the advantages of drawn or rolled aluminium or aluminium-alloy sections, as regards life and ease of painting without ground coat on a smooth surface, have naturally led us to generally employ these light metals for the lining of all body parts above the waist rail, and for all mouldings and window frames. Consequently all sheets, plywood and wooden mouldings have been completely eliminated.

Wood has been retained only for battens, which have been reduced in volume and weight, for fixing the trimmings by means of wood screws. We consider, in fact, that apart from a few exceptional cases, the easy construction and maintenance provided by this method of fixing, which avoids the multiple drawbacks of trimming by means of small metal screws, needs no confirmation.

The use of aluminium alloys, in the form of duralumin, has been further extended to small secondary partitions and window balances.

An important application of special aluminium alloy with 5.5 to 7 % magnesium content (Duralinox) was made in the fabrication of sliding doors, both interior and exterior.

Finally, the components generally designated as « fittings » i.e. hand rails, door handles, luggage racks, locksmith's work, lighting appliances, have been entirely re-designed in light metals, as also have the third-class seat frames.

On principle, bronze aluminium has been used for the castings to be painted, and the anti-corrosive magnesium-base alloys, suitable for polishing, used for the fittings, contribute to the decoration.

Seats. — Wood-lath seats, specially designed for comfort, having given marked maintenance savings in our 3rd-class suburban stock, they have been retained, but all their components have been lightened — the woodwork by reduction in volume, and the metal supports by the substitution of Alpax for the steel pressings.

The weight of the seats is 8 to 9 kgr. per passenger according to the number of places.

In the first/second class an appreciable increase in comfort has been achieved by the use of seats for four passengers, symmetrically placed in relation to the central aisle (instead of seats with six places in one case and four places in the other, see diagram, figure 3).

Fig. 13. — First and second-class seat frames made of welded steel tubes.

The new seats have an interesting welded chromium-steel frame (fig. 13), weighing only 15 kgr. (33 lb.) for four places. The individual seats and backs are upholstered in velvet over steel wire springs and finished off with leather trimmings.

The weight of the whole is about 59 kgr. (130 lb.), or 14.7 kgr. (32 1/2 lb.) per place.

Windows. — We must also mention amongst the weight saving measures adopted, the reduction in thickness, from 7 to 6 mm. (9/32 in. to 1/4 in.), of the large safety glass window lights, made possible by the recent progress in the manufacture of safety glass.

The total weight reduction achieved by the various arrangements in connec-

tion with the interior fittings and trimmings used, compared with former methods, is about *3 100 kgr. (6 834 lb.)* per vehicle.

IV. — *Various arrangements and devices : Brake. — Heating. — Special features of sliding doors. — Remote control of the outside doors. — Pneumatic passenger communication.*

The Westinghouse brake is of the current type now used on the French Railways, without any special devices. The brake vans have, in addition, a hand brake which can be utilised in normal working, whilst lavatory vehicles have also a hand brake for use in special working.

The heating system, of the Westinghouse lightened type (bronze aluminium radiators), has given a weight reduction of 1 060 kgr. (2 218 lb.), as compared with the former Westinghouse system with cast steel thermostatic heating elements.

The interior and exterior sliding doors, (as well as the end communication doors for the staff) are made of magnesium-base aluminium alloy (Duralinox), of a patent manufacture with special lap-jointing without rivetting or welding. In this way their leaves can be perfectly even — an essential condition of good fitting, adjustment and sliding.

They have also some other very interesting features : adjustment of the position in the vertical plane and adjustment of the vertical equilibrium by eccentric cams, remote control of the locks, avoiding the dangerous projection of bolts or catches, and allowing of the provision of a door handle accessible to passengers standing on the platform without their being obliged first to get unto the footboard, and rubber shock absorbers which also form a tight fitting, easily fixed and removed.

— The Est system of remote control of the closing of exterior sliding doors, operated after the style of a direct brake by the simple emission of air from a valve worked by the guard in the brake compartment at the front or rear of the train, has given complete satisfaction on existing suburban coaches. It has allowed us to dispense with the use of electro-valve relay systems, and has therefore been retained for the new stock, at the same time being improved by a recuperative pneumatic device, which frees the doors from the operating piston after closing as soon as the driver relieves the pressure in the main brake pipe.

This device is combined with an automatic quick-discharge valve which ensures the direct exhaust of each piston cylinder to the atmosphere and thus

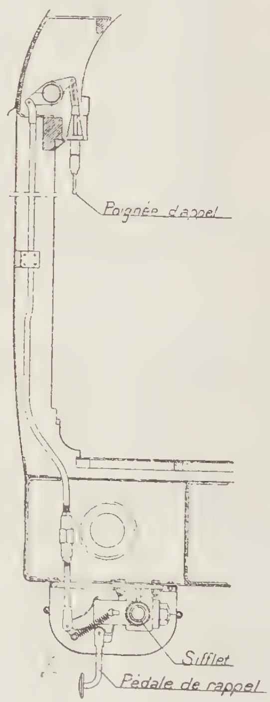


Fig. 14. — New passenger communication operating gear.

Note : Poignée d'appel = emergency brake handle. — Sifflet = whistle. — Pédale de rappel = resetting pedal.

avoids the delay in opening the doors which results from a remote bulk discharge from the main pipe and the driver's valve.

— The coaches will be equipped with an entirely new pneumatic passenger communication device (fig. 14), the principal feature of which is the use, as a means of transmission from the emergency brake handle to the clap valve of the alarm whistle, of a torsion tube in place of a draw-wire. This device obviates all the working and maintenance difficulties resulting from excessive friction of the draw-wire in the guides, a trouble which we had not previously been able to eliminate from our stock.

V. — *Increased comfort. Sound insulation.*

Increased comfort has been, ever since the introduction of the metal coaches, the subject of renewed research.

A particularly interesting improvement has been made for the first time on our lightened suburban vehicles by the general sound-insulation of the framework and linings, including the flooring, by resorting to a process called « Flockage », which has already been employed on warships and certain recently built liners. This process consists of spraying on an adhesive agent and pulverised textile matter.

It will be seen hereafter that this heat and sound insulating material also solves the corrosion problem. It is, moreover, water and fireproof.

This lining has enabled us to dispense with the « molleton » lining which, in our previous vehicles, had already contributed a great deal towards deadening vibrations and noise. Its weight is 500 to 600 gr. per m² (1.64 to 1.97 oz. per sq. ft.) when two coats are applied, i.e. less than 400 kgr. (880 lb.) per vehicle.

Amongst the steps taken to increase comfort, the following must be mentioned : — extensive use of rubber in the suspension, mentioned above (see bogies); decreased inertia and general improvement in the working of the light-metal sliding doors; widening of the body, a width of 470 mm. (18 1/2 in.) instead of 460 mm. (18 1/4 in.) per passenger being provided in 3rd-class compartments; leather seats for two or three passengers in the second class replaced by individual seats upholstered in velvet and grouped in pairs, giving 545 mm. (21 1/2 in.) width per place instead of 460 mm. (18 1/4 in.).

VI. — *Steps taken to prevent corrosion.*

Several years' experience with nearly 500 vehicles in service, main-line as well as suburban, has shown the excellent preservation of plates shaped and assembled with a view to the immediate discharge of condensed moisture — drain channels at the bottom of the coach walls, ventilating pipes for the frame strengthening plates, forming spark traps.

The condition of the linings when coaches are stripped for general repairs has shown us that graphite paint has perfectly protected all the framework plates, which have remained intact. Consequently these general arrangements have not been altered on the new coaches and we have, in particular, been able to retain the very simple method of fixing frameless lights, without waist-joint, balanced by the « Hera » device. This device offers incomparable advantages, as regards simplicity of construction and maintenance.

Moreover, as the heat and sound insulating medium, called « Flockage » and described above, has remarkable anti-corrosive properties, which have been fully verified in our laboratories on specimen plates subjected for 500 hours to a brine-vapour test, we have discontinued the double coat of graphite paint and provided, by the new process a much more efficient coating of all frame-

work assemblies, into the interstices of which destructive dampness might otherwise penetrate by capillarity.

Conclusion.

The whole of the arrangements described above, besides a definite increase in comfort, will give a weight saving estimated at 9.5 t. (9.3 Engl. tons) or 23 % (32 tonnes instead of 41.7 tonnes for a third-class coach).

The additional cost involved is lower than was anticipated. It will not in fact exceed 45 000 francs per unit, the comparison of the costs of the new coaches with those of the previous order (1932) taking into account the general decrease in rolling stock prices which occurred since that date.

It can be said, broadly speaking, that two thirds of this sum are due to the weight saving measures and one third to the increased comfort (1).

(1) These figures are based on March 1936 contract prices.

[656. 222.1]

Note on Train Speeds,

by LIONEL WIENER,
Professor at the University of Brussels.

PART II *(Continued)* [1]

Train speeds and services in different countries.

XXI. — EUROPE.

CONTENTS.

CHAPTER LIX.

Speeds.

LIX-1. — **Progression of speed.** — Generally speaking, speed has everywhere increased continuously and this is likely to continue if railways are to fight air and road transport competition. A very striking idea of recent progress can be gathered when comparing Table 28 [2] which gave the highest average speeds of non-stop runs in 1933 with Table 347 hereafter which gives the same information, brought down to-date. The increase in four years has been some 10 %.

(1) Cf. *Bulletin of the Railway Congress,* October and November 1933; January, May June and July 1934; February, March, April, May, July and October 1935; March, May June, July and August 1936; February, August and October 1937.

(2) See *Bulletin of the Railway Congress,* October 1933, p. 919/35.

Fig. 428. — Cartogram of the French Railways, showing the maximum average speeds.

To be read as figure 429.

Note. — Rapides running at over 100 km. (62 miles) an hour also run on the Laigle-Alençon, Le Mans-Sablé and Angers-Nantes sections.

Figures 428 and 429 compared with figures 32 and 138 [1] giving cartograms of the maximum average speeds in France and Belgium also show the progress made. Generally speaking each line has gone one step up : the maximum average speeds of 70 to 80 km. (43.5 to 50 miles) an hour have risen to between 80 and 90 km. (50 and 56 miles); those of 80 to 90, are now over 90, and so on. Relatively few lines have maximum average speeds between 95 and 100 km. (59 and

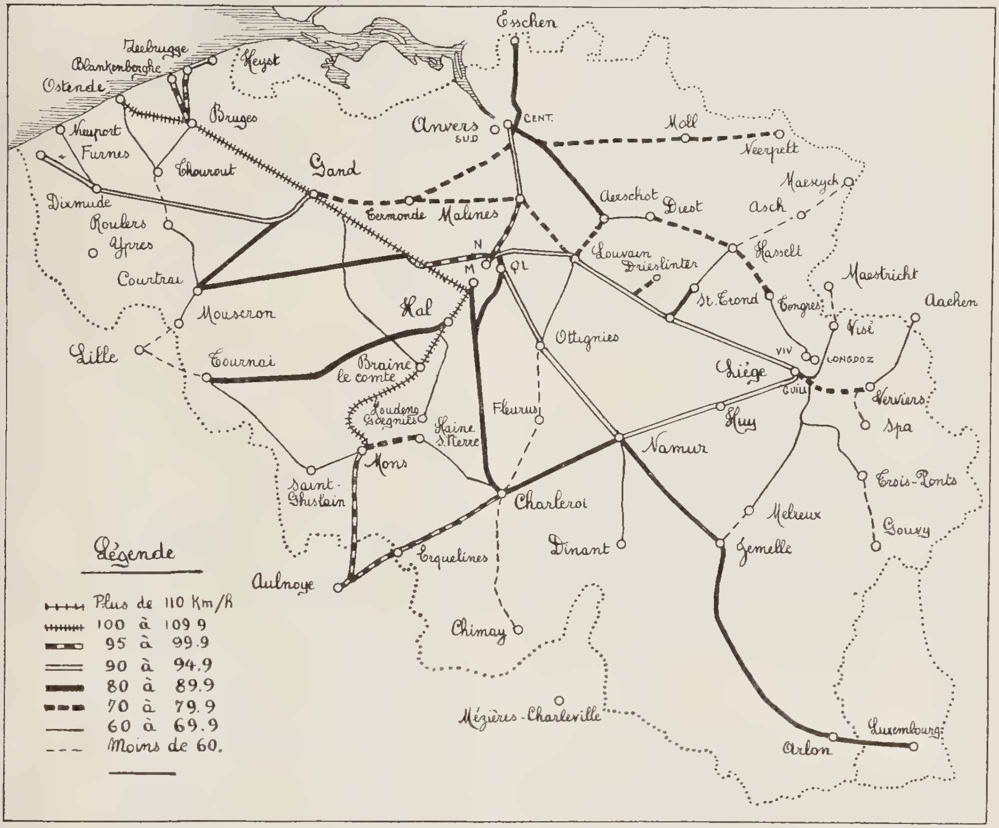


Fig. 429. — Cartogram of the Belgian railway system showing the maximum average speeds.
Note. — Plus de 110 km./h. = over 110 km. (68.4 miles) an hour. — Moins de... = under.

62 miles) an hour, for when a line is suitable for speeds exceeding 90 km. (56 miles) an hour, it can usually accommodate much higher speeds than these.

Such running has caused the maximum authorised speed to be raised above the 120 km. (75 miles) an hour which has ruled in France and Belgium since 1853.

On lines equipped with automatic si-

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(1) *Bulletin of the Railway Congress,* May 1934 and February 1935, pp. 408/153 and 207/347 respectively.

gnalling, the *French Nord*'s metal stock trains are allowed to run at 130 km. (80.8 miles) an hour, and shortly, at 140 km. (87 miles); this applies in particular to the Paris-Creil-Tergnier and Arras lines (October 1936). A speed of 130 km. (80.8 miles) an hour is allowed on certain of the *Etat* lines, 125 (77.7 miles), on the *Est* and 130 (80.8 miles) on the *Paris Orleans-Midi*'s electrified line.

In Belgium, a maximum speed of 140 km. (87 miles) an hour is allowed between Ghent and Bruges and between Brussels and Mons [save through the Braine-le-Comte station, where the speed is restricted to 120 km. (75 miles) an hour, and near Mons, where 40 km. (25 miles) only is allowed]. Railcars can run at these or higher speeds without in any way affecting their safety.

In the U.S.A., for instance, during 1935 not a single passenger was killed on the railway. In England where the traffic is five times as heavy (double that of France and Germany) out of 1 179 462 000 passengers carried during 1936, only three were killed, i.e. 1 out of 393 000 000, whereas road traffic kills nearly 20 a day, and 24 000 every year in the United States.

LIX-2. — **Geographical distribution of high speeds.** — In previous chapters, we have reviewed the physical, economic and political conditions which have affected the location of railways, and later, their operation, and for each of them, we drew up a table showing the highest average speeds and the longest non-stop runs.

Thes fastest runs are no longer concentrated in Western Europe only; they extend to part of Central Europe and are to be found in England, France, Belgium, Germany, Denmark and Italy, but the progress differs materially from one country to another. After taking the lead some years ago, Great Britain has done little except in a few cases to further increase high speeds. France has extended them practically to all its « rapides ». A very marked increase characterises German and American runs which are now in the vanguard, whereas an agreement between the formerly competitive Canadian Companies (*Canadian Pacific* and *Canadian National Rys.)* had led to speed reduction.

All Belgian « block » (set) trains have been speeded up and all the Danish lines linking up Copenhagen with Jutland now have faster services. In Italy, electric traction has progressed most, whereas the speed of railcars and steam trains has been reduced.

Table 339 gives total mileages having over 100-km. (62 miles) an hour average speeds and shows the proportion lying to the credit of each European country.

Only France and Germany have large mileages, France heading the list, but Germany is the only European country having trains booked at over 120 km. (75 miles) and even 130 km. (80.8 miles) average speed. It is surprising that after having led so many years, England should have been left so far behind.

Denmark and Belgium's mileages are fair in view of their small size. Italy is the last comer in the list and whilst its former 263 km. (163.4 miles) railcar run at 100 km. (62 miles) an hour can no longer be included in the table [1], she retains her place owing to the inclusion of her first « electrotrain ».

In all our articles, we have always considered mileages of lines run over at various given speeds. This implicitely

(1) Between Milan and Venice Santa Lucia until the 21st May 1937.

TABLE 339.

MILEAGE OF EUROPEAN LINES WHOSE TRAINS AVERAGE OVER 100 KM. (62 MILES) AN HOUR.

COUNTRIES.	100 to 109.9 km. (62 to 68.4 miles) per hour.		110 to 119.9 km. (68,5 to 74.4 miles) per hour.		120 to 129.9 km. (75 to 80.9 miles) per hour.		130 to 139.9 km. (81 to 86.4 miles) per hour.		Total.	
	Km.	Miles.	Km.	Miles.	Km.	Miles.	Km.	Miles.	Km.	Miles.
France	1 809	1 124.1	1 679	1 043.3	...	...	...	...	3 488	2 167.4
Germany	1 458	906.0	176	109.4	693	433.7	596	370.3	2 928	1 819.4
Great Britain . .	312	193.9	513	318.8	...	...	...	...	825	512.7
Denmark	111	69.0	242	150.4	...	...	...	...	353	219.4
Italy	97	60.3	210	130.5	...	...	...	...	307	190.8
Belgium	138 (1)	85.7 (1)	...	...	...	...	...	...	138	85.7
TOTAL.	3 925	2 439.0	2 820	1 752.4	698	433.7	596	370.3	8 039	4 9[illegible]5.4
PERCENTAGES OF TOTAL.	48.8		34.9		8 7		7.6		100	

takes the technical progress made by the mechanical and engineering departments into account. Thus, whether a single or ten trains run non stop from Paris to St. Quentin [153 or 1 530 km. (95.1 or 951 miles)], technics are not affected; the difference only concerns traffic density. But were these ten trains to serve ten different lines at this same speed, this would supply us with valuable information applying to a ten times larger portion of the railway system. Now in England papers usually only deal with the number of train-miles covered at various speeds without any reference to the proportion of the railways compared with the total system which would enable useful inter-railway comparisons to be made.

As we have upheld this opinion for many years, it gives us all the more pleasure to see that Mr. Cecil J. ALLEN shares it in an interesting article recently published in *The Railway Gazette* (2). He quotes, amongst others, not only the total fast train-miles (over 60 miles or 96 km. an hour), but also the ratio of this train-mileage to the total mileage, just as we have done in our previous articles in this series.

Timetables. — We have used the official timetables for the 22nd May 1937 when quoting the speeds.

LIX-3. — **Apportionment between methods of traction.** — The economic and physical conditions in each country differ a great deal, so that each of them, according to its own requirements and resources, has had recourse to the various methods of traction available. Consequently it is necessary to consider the

(1) This does not include the 203 km. (126.1 miles) from the French frontier to Brussels and Liége, where trains average from Paris over 100 km. (62 miles) an hour, and less than this in Belgium.

(2) *Railway Gazette*, 30th April, 1937.

Fig. 430. — Cartogram of European railways having runs whose average speed exceeds 100 km. (62 miles) an hour.

Heavy lines represent speeds of 100 to 109.9 km. (62 to 68.4 miles) p. h.
Single-crossed lines, speeds of 110 to 119.9 km. (68.5 to 74.4 miles) p. h.
Double-crossed lines, speeds of 120 to 129.9 km. (75.0 to 80.9 miles) p. h.
Triple-crossed lines, speeds of 130 to 139.9 km. (81.0 to 86.4 miles) p. h.

use made of each method separately, both as regards fast runs and long non-stop runs, before dealing with the combined use of various methods, which is the practice on certain railways.

(a) **Railcar services.** — Because of their widespread use, it is often lost sight of that railcars are of quite recent introduction; when we began to write these articles, they were merely experimental

TABLE 340.

FASTEST RUNS AND LONGEST NON-STOP RUNS MADE BY RAILCARS IN THE DIFFERENT EUROPEAN COUNTRIES.

Serial number.	COUNTRY.	Railway.	RUN.	Distance Km.	Distance Miles.	Time of departure.	Time spent.	Speed Km./h.	Speed M.p.h.	Name of train.
			Fastest runs.							
1	Germany.	Reichsbahn.	(Berl. Stadtb.) Hanover-Hamm	177	110.0	**9.19** p. m.	1.20	137.9	85.7	...
	Do.	Lübeck-Büchen.	Lübeck-Hamburg	63	39.1	**1.11** p. m.	0.40	84.6	52 6	...
—	U.S.A.	Santa Fe.	*La Junta-Dodge City*	326	202.0	...	*2.25*	*134.6*	*83.7*	*The Super Chief.*
2	France.	P.L.M.	(Paris) Laroche-Dijon (Lyons).	159	98.8	**9.20** a. m.	1.22	116.4	72.4	...
	Do.	Nord.	Paris Nord-Longueau (Lille) .	126	78.3	**10.25** a. m.	1 05	116.3	72.3	...
	Do.	State.	Paris St.-Lazare-Havre . . .	228	141.7	**8.05** a. m.	1 58	115.9	72.0	...
	Do.	Est.	Paris Est-Bar le Duc (Nancy)	254	157.8	**7.50** p. m.	2.14	113.9	70.8	...
	Do.	Alsace-Lorraine.	Strasbourg-Nancy (Paris) . .	150	93.2	**6.00** a. m.	1.20	112.5	69.8	...
	Do.	P.O.-Midi.	Poitiers-Châtellerault	33	20.5	**8.35** a. m.	0.22	90.1	56.0	...
3	Gr.-Britain.	Gt. Western Ry.	Castle Cary-Westbury. . . .	32	19.9	**11.06** a. m.	0.18	106.1	65.9	...
—	Italy.	State.	*Torino P Susa-Milan Cent. (1936/37)*	147	91.3	*6.44 a. m.*	*1.24*	*105.0*	*65.3*	*To Venice.*
4	Denmark.	Do.	Roskilde-Skagelse	61	37.9	**8.02** a. m.	0.36	101.7	63.2	The Vesterhavet.
5	Belgium.	Nat. Rys. Co.	Brussels Midi-Heyst (summer)	110	68.3	**11.36** a. m.	1.05	101.5	63.1	...
6	Italy.	State.	Venice S.L.-Cervignano (Trieste).	112	69.6	**9.23** p. m.	1.09	97.3	60.5	...
7	Czechoslovakia.	Do.	(Prague) Brno-Bratislava . .	142	88.2	**9.27** p. m.	1.28	96.8	60.2	The Blue Arrow.
8	Poland.	Do.	Warsaw Gl.-Koluski-Lodz Fab.	130	80.8	**10 25** a. m.	1.28	95.5	59.3	3 times daily.
9	Hungary.	Do.	Budapest Keleti-Vienna W. .	271	168.4	**7.10** a. m.	2.57	91.9	57 1	The Arpad.
10	Spain.	Norte.	Madrid Norte-Villalba . . .	38	23.6	**5.15** p. m.	0.30	76.0	47.2	...
11	Austria.	Federal.	(Vienna) Brück-Strass Sommerein	41	25.5	**7.45** a. m.	0.33	74.5	46.3	...
			Longest runs.							
1	Germany.	Reichsbahn.	(Berl. Anh.) Nuremberg-Leipz.	322	200.1	**8.29** a. m.	3.33	86.0	53.4	*FDt* train.
2	Hungary-Austria.	State.	Budapest Keleti-Vienna W. .	271	168.4	**7.10** a. m.	2.57	91.9	57.1	The Arpad.
3	Italy.	Do.	Milan Cent.-Venice Mestre . .	258	160.3	**8.18** a. m.	2.44	94.4	58.6	...
4	Czechoslovakia.	Do.	Prague Wils-Brno (Bratislava)	255	158.4	**6.35** p. m.	2.49	90 5	56.2	The Blue Arrow.
5	France.	Est.	Paris E.-Bar le Duc (Nancy) .	254	157.8	**7.50** p. m.	2.14	113.9	70.8	...
	Do.	State.	Paris-St. Lazare-Havre . . .	228	141.7	**8.05** a. m.	1.58	115 9	72.0	Several times a day.
	Do.	P.L.M.	(Paris) Dijon-Lyons	197	122.4	**10.54** a m.	1.45	112.6	70.0	...
	Do.	Nord.	Paris-St. Quentin (22 Mai 1937)	153	95.1	**8.15** p. m.	1.20	114.8	71.3	To Brussels.
	Do.	P.O.-Midi.	St.-Pierre des Corps-Vierzon .	109	67.7	**5.32** p. m.	1.22	79.9	49.6	...
	Do.	Alsace-Lorraine.	Strasbourg-Nancy (Paris) . .	150	93.2	**6.00** a. m.	1.20	112.5	69.8	...
6	Denmark.	State.	Nyborg-Aarhus	198	123.0	**10.24** a. m.	2.06	94.3	58.6	The Kronjyden.
7	Belgium.	Nat. Rys. Co.	Furnes-Brussels Midi (summ.)	133	82.6	**10.06** p. m.	1.24	95.0	59.0	...
8	Poland.	State.	Warsaw Gl.-Lodz Fab. . .	130	80.8	**10.25** a. m.	1.28	95.5	59.3	Several times a day.
9	Austria.	Federal.	Semmering-Vienna	103	64.0	**11.46** a. m.	1.34	65.3	40.6	From Graz.
10	Gr.-Britain.	Gt. Western Ry.	Birmingham-Cheltenham Spa .	87	54.0	**9.05** a. m.	1.00	86.9	54.0	...

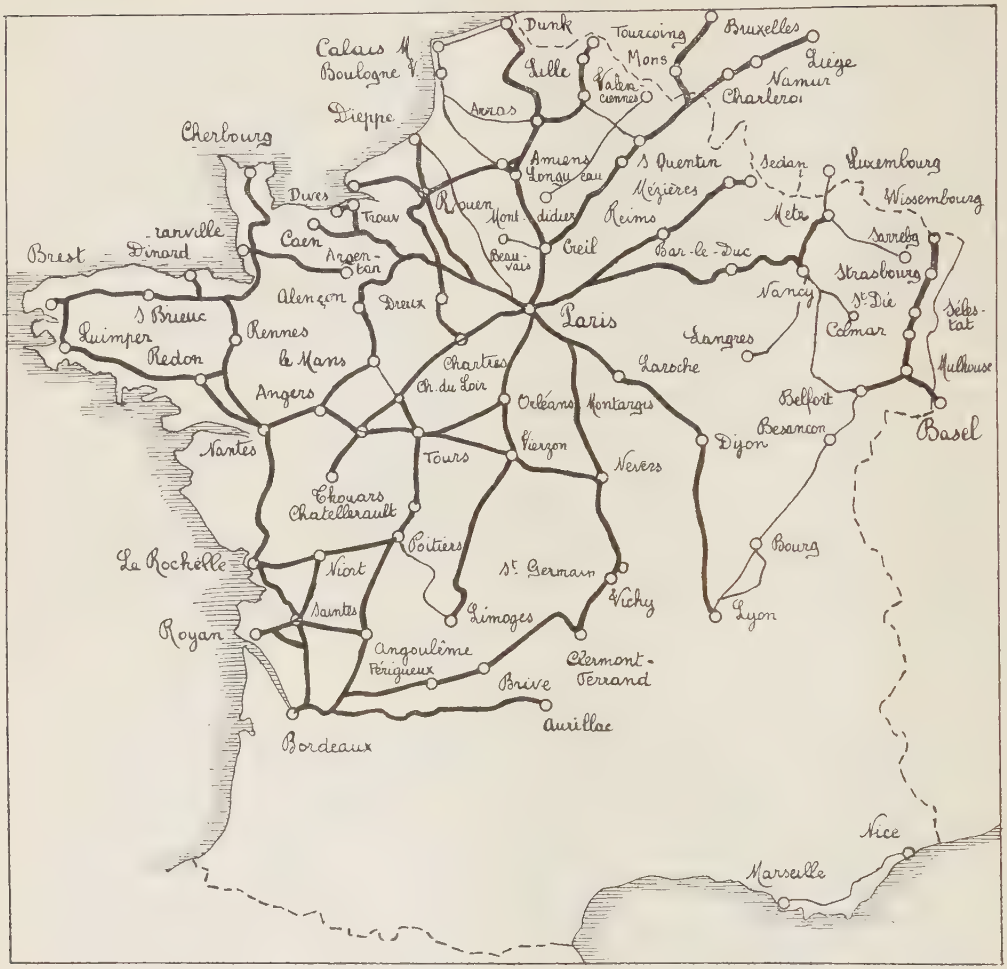

Fig. 431. — Map of fast French « rapides » railcar services (heavy lines).
In addition a few « express » railcar services are also shown (thin lines).

vehicles that were being tried out. To-day, not only are they definitely established, but it is even possible to select the services for which they are most suitable, leaving the others to be worked by electric or steam traction. Indeed, the diesel vehicle is particularly suited for short fast runs, for which its great power of acceleration is particularly valuable, and for long non-stop runs. To work such services, in Germany, Belgium, Denmark, Holland and Spain, double, triple or quadruple sets are used, all of which are articulated except on the *French Nord*.

Single fast railcar services are run in England, Poland, Czechoslovakia, Austria and Hungary, while both kinds exist in France and Italy.

Table 340 shows the fastest and longest non-stop runs of each European Railway.

In countries where several Companies operate these are grouped, the leading Railway heading the list and the others following in proper order. This is clearer than showing all railways according to their place in whatever country they happen to be in. This applies to the several British and French Railway Companies.

As will be seen, Germany heads the list both for the fastest run and for the longest non-stop run.

As regards speed, Germany, France, England, Denmark, and Belgium all have railcar services run at over 100 km. (62 miles) an hour, and four other countries — Italy, Czechoslovakia, Poland and Hungary — at 90 to 100 km. (56 to 62 miles).

Non-stop runs over 200 km. (125 miles) long, occur in five countries — Germany, Hungary-Austria, Italy, Czechoslovakia and France —; Denmark comes just below with a 198-km. (123 miles) non-stop run.

Several other railcar services have interesting features which we shall run over, taking them in the order we have previously followed.

1. — GREAT BRITAIN. — No new services.

2. — FRANCE. — The six main-line companies have services radiating from Paris, and most of them inter-provincial services as well (fig. 431).

(a) Services radiating from Paris :

NORD. — To Lille and Tourcoing (3 daily trips each way).

To Brussels and also to Liége (from the 22nd May 1937 at the same speed as the existing « rapides », but with additional intermediate stops).

EST. — To Mézières-Charleville and Sedan (since 1936).

To Nancy, extended since this summer to Strasbourg.

P.L.M. — To Lyons (twice daily).

To Vichy and Clermont-Ferrand (the oldest of these services).

STATE. — To Trouville-Deauville (several times a day).

To Havre (several times a day).

To Dieppe.

A detailed list of these runs and of the principal non-stop runs is given in tables 341*a* and *b*.

(b) Cross-country services :

NORD. — Lille-Havre.

ALSACE-LORRAINE. — Strasbourg-Basle and Strasbourg-Belfort-Lyons.

P.L.M. + P.O. — Vichy to Le Mans.

P.O.-MIDI. — Bordeaux-Aurillac and Bordeaux-Clermont-Ferrand.

STATE. — Dieppe-Maritime to Nantes.

The last one is a particularly noteworthy boat service as it uses, often at high speed, between Dieppe and Nantes, a number of sections of different cross-country lines (1).

As will be seen, all railways listed hereunder have large mileages of railcar services covered at over 100 km. (62 miles) an hour.

P.L.M.	766 km. (476 miles)
STATE	721 km. (448 miles)
NORD.	615 km. (382 miles)
EST	515 km. (320 miles)
ALSACE-LORRAINE . . .	233 km. (145 miles)
P.O.-MIDI	0 —

(1) The exact length of each section is as under :

Dieppe Town-Rouen . .	60.6 km.	(37.6 miles)
Rouen-Serquigny-Laigle.	125.8 km.	(78.2 miles)
Laigle-Surdon-Alençon .	66.1 km.	(41.1 miles)
Alençon-Le Mans . . .	55.9 km.	(34.7 miles)
Le Mans-Sablé. . . .	47.9 km.	(29.8 miles)
Sablé-Angers	48.8 km.	(30.3 miles)
Angers-Nantes P.O. . .	87.5 km.	(54.4 miles)
Total.	492.6 km.	(306.1 miles)

Table 341*a*.

FAST RAILCAR SERVICES RADIATING FROM PARIS.

Certain other interesting railcar services are also given in *italics*.
Non-stop runs are shown in **heavy type.**

Railway.	Run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Number of stops.	Speed. Km./h.	Speed. M.p.h.	Class of train.
Nord.	Paris N.-Amiens-Lille	258	160.3	11.50 a. m.	2.35	3	92.8	57.7	Rapide.
	Paris-Amiens	131	81.4	**Do.**	**1.13**	...	**107.6**	**66.9**	Do.
	Paris-Longueau	126	78 3	**10.25** a. m.	**1.05**	...	**116.3**	**72.3**	Do.
	Amiens-Arras	68	42.3	**1.06** p. m.	**0.37**	...	**110.3**	**68.5**	Do.
	Arras-Douai	25	15.5	**1.44** p. m.	**0.16**	...	**93.8**	**58.3**	Do.
	Douai-Lille	34	21.1	**2.01** p. m.	**0.24**	...	**85.0**	**52.8**	Do.
Nord and Belgium.	Paris N.-Brussels Midi	311	193.3	8.15 p. m.	3.00	3	103.7	64.4	Rapide.
	Paris N.-St. Quentin	153(1)	95.0(1)	**Do.**	**1.20**	...	**114.8**	**71.3**	Do.
	St. Quentin-Aulnoye	62	38 5	**9.36** p. m.	**0.35**	. .	**106.3**	**66.1**	Do.
	Aulnoye-Mons	34	21.1	**10.12** p. m.	**0.23**	...	**88.7**	**55.1**	Do.
	Mons-Brussels Midi	61	37.9	**10.36** p. m.	**0.39**	...	**93.8**	**58.3**	Do.
Nord and Belgium.	Paris N.-Liége Guillemins	367	22.8	8.10 p. m.	3.50	7	95.7	59.5	(Belg.Nat.Ry Rapide.
	Jeumont-Charleroi	32	19.9	**10.27** p m.	**0.33**	...	**58.2**	**36.2**	Nord-Belge
	Charleroi-Namur	37	23.0	**10 51** p. m.	**0.26**	...	**85.4**	**53.1**	(Belg.Nat.Ry
	Namur-Huy	30	18 6	**11.18** p. m.	**0.20**	...	**90.0**	**55.9**	Nord-Belge
	Paris Est-Longueville	*89*	55.3	*9.06* a. m.	*0.56*	...	*95.3*	*59.2*	*Express.*
Est.	Paris Est-Sedan	261	16.2	5.06 p. m.	2.47	3	93.8	58.3	Rapide.
	Paris Est-Reims	156	96.9	**Do**	**1.32**	...	**101.7**	**63.2**	Do.
	Paris Est-Strasbourg	503	312.6	7.50 p. m.	4.35	2	109.8	68.2	Do.
	Paris-Bar le Duc	254	157.8	**Do.**	**2.14**	...	**113.9**	**70.8**	Do.
	Bar le Duc-Nancy	99	61.5	**10.06** p. m.	**0.56**	...	**106.0**	**65.9**	Do.
Est and Alsace.	Nancy-Strasbourg	150(2)	93.3(2)	**R 6.00** a. m.	**1.20**	...	**112.5**	**69.9**	Do.
P. L. M.	Paris P.L.M.-Lyons	512	31.8	8 00 a. m.	4.39	2	110 1	68.4	Rapide T.A
	Paris-Laroche	156	96.9	**Do.**	**1.28**	...	**105.0**	**65.2**	Do.
	Laroche-Dijon	159	98.8	**9.29** a. m.	**1.22**	...	**116 4**	**72.3**	Do.
	Dijon-Lyons	197	122.4	**10.54** a. m.	**1.45**	...	**112.6**	**70.0**	Do.
	Paris-Clermont-Ferrand	410	254.8	4.00 p m.	4.20	6	94.6	58.8	Rapide T.A
	Paris-Montargis	118	73 3	**Do.**	**1.07**	...	**105.7**	**65.7**	Do.
	Montargis-Nevers	136	84.5	**5.08** p. m.	**1.15**	...	**108.8**	**67.6**	Do.
	Nevers-Moulins	60	37.3	**6.24** p. m.	**0.38**	...	**94.7**	**58.9**	Do.
State.	Paris-Rennes-Brest	249	154.7	12.20 p. m.	3.03	2	81.6	50 7	Rapide.
	Paris St. Lazare-Trouville (Summer)	221	137.3	**2 10** p. m.	**2.00**	...	**110.5**	**68.7**	Do.
	(Paris) Lisieux-Trouville	*30*	*18.6*	*7.45* a. m.	*0.25*	5	*72.0*	*44.7*	*Do.*
	Paris St. Lazare-Havre	228	141.7	**8.05** a. m.	**1.58**	...	**115.9**	**72.0**	Do.
	Paris St. Lazare-Rouen	140	86 7	**2.05** p. m.	**1.13**	...	**115.1**	**71.5**	Do.
	Rouen-Havre	88	54.7	**3.19** p. m.	**0 46**	...	**114.8**	**71.3**	Do.
	Paris St Lazare-Dieppe Town	169	105.0	**R 6.56** a. m.	**1.47**	...	**94.7**	**58.9**	Do.

(1) The exact distance is 153.1 km. (95.1 miles).
(2) Including 57 km. (35.4 miles) on the *Est Ry.*, from Igney-Avricourt to Nancy.

Table 341*b*

FAST CROSS COUNTRY RAILCAR SERVICES.

Non-stop runs are shown in **heavy type**, expresses in *italics*.

Railway.	Run.	Distance Km.	Distance Miles.	Time of departure.	Time spent.	Number of stops.	Speed Km./h.	Speed M.p.h.	—
tate + Nord.	Havre-Rouen-Lille	335	208.2	6.40 p. m.	3.40	5	91.4	56.8	Rapide.
Nord.	Rouen-Serqueux	48	29.8	**7.36** p. m.	**0.39**	...	**72.3**	**44.9**	Do.
	Serqueux-Amiens	71	44.1	**8.15** p. m.	**0.47**	...	**90.6**	**56.3**	Do.
	Lille-Arras-Boulogne	187	116.2	8.19 a. m.	3.01	5	66.8	41.5	Do.
	Lille-St. Pol-Boulogne	162	100.7	R 8.11 p. m.	2.40	4+5 opt.	60.7	37.7	Do.
ls.-Lorraine.	Strasbourg-Wissembourg	68	42.3	5.46 p. m.	0.50	2	81.6	50.7	Do.
	Strasbourg-Basle	142	88.2	10.28 a. m.	1.44	5	81.1	50.4	Do.
	Strasbourg-Colmar	66	41.0	**11.23** a. m.	**0.37**	...	**107.0**	**66.5**	Do.
	Colmar-Mulhouse	42 (3)	26.1 (3)	**12.01** p. m.	**0.26**	...	**90.9**	**56.5**	Do.
	Mulhouse-St. Louis	27	16.8	**11.47** a. m.	**0.17**	...	**95.4**	**59.3**	Do.
	Mulhouse-Belfort	49	30.4	**12.30** p. m.	**0.30**	...	**86.0**	**53.4**	Do.
P.L.M.	Belfort-Besançon-Lyons Brot.	310	192.6	*1.08* p. m.	*3.51*	*7*	*89.2*	*55.4*	*Express, T.A.*
P.O.-Midi + P.L.M.	Le Mans-Saincaize-Vichy	478	297.0	1.32 p. m.	5.39	9	84.3	52.4	Exp. + Rap.
P.O.-Midi.	Bordeaux-Bergerac-Aurillac	285 (1)	177.1 (1)	3.10 p. m.	5.10	23	55.2	34.3	Rapide.
	Bordeaux-Countras-Clermont Ferrand	245 (1)	152.2 (1)	7.20 a. m.	6.39	21	36.8	22.9	Do. BBC.
State.	Dieppe Mar.-Nantes	503	312.6	6.07 a. m.	5.11	7	97.7	60.7	Rapide, DCN «Manche-Océan».
	Dieppe Town-Rouen	61 (2)	37.9 (2)	**6.15** a. m.	**0.34**	...	**106.9**	**66.4**	Do.
	Rouen-Serquigny-Laigle	126 (2)	78.3 (2)	**6.50** a. m.	**1.20**	..	**94.3**	**58.6**	Do.
	Laigle-Surdon-Alençon	66 (2)	41.0 (2)	**8.11** a. m.	**0.39**	...	**101.6**	**63.3**	Do.
	Alençon-Le Mans	56 (2)	34.8 (2)	**8.51** a. m.	**0.33**	...	**101.6**	**63.3**	Do.
	Le Mans-Sablé	48 (2)	29.8 (2)	**9.29** a. m.	**0.28**	...	**102.8**	**63.9**	Do.
	Sablé-Angers	49 (2)	30.4 (2)	**9.58** a. m.	**0.30**	...	**97.6**	**60.4**	Do.
	Angers-Nantes P.O.	88 (2)	54.7 (2)	**10.29** a. m.	**0.49**	...	**107.1**	**66.5**	Do.
	Bordeaux-Saintes	111	69.0	8.08 p. m.	1.29	3 opt.	74.4	46.2	Rapide.
	Saintes-La Rochelle	74	46.0	**R 8.05** a. m.	**0.55**	...	**80.9**	**50.3**	Do.
	Bordeaux-Saujon (Royan)	140	87.0	**7.45** a. m.	**1.53**	...	**74.3**	**46.2**	Rapide, BMR.

(1) Excluding the 5 km. (3.1 miles) added for rating purposes since the Bordeaux bridge (nearly 500 m. = 1 640' long) was opened to traffic.

(2) Exact distances are given page 2109.

(3) 25 km. (15.5 miles) from Colmar to Bollweiler and 17 km. (10.6 miles) from Bollweiler to Mulhouse.

Total, 2 091 km. (1 771 miles) (1).

In 1936 rapides ran over 15 475 km. (9 616 miles) i.e. 37 % of the total French railway system of 41 910 km. (26 042 miles). Of this mileage :

1 143 km. (710 miles), i.e. 3 %, had fast railcars;

9 335 km. (5 801 miles), i.e. 22 %, had electric or steam trains;

4 988 km. (3 099 miles), i.e. 12 %, had both kinds of trains.

The railcar services were further extended in 1937.

4. — BELGIUM. — Belgium is the only European country whose railcars are booked to run to the same timings as the steam trains which take their place when traffic requires it (See « block » trains).

6. — ITALY. — Pending completion of the general electrification scheme, « rapidi » railcars now run, usually as single units, exceptionally in three-car sets, both on certain continental and most Sicilian main lines. They have been abandoned in southern Italy where they were insufficiently patronised, but are retained in northern and central Italy (fig. 432).

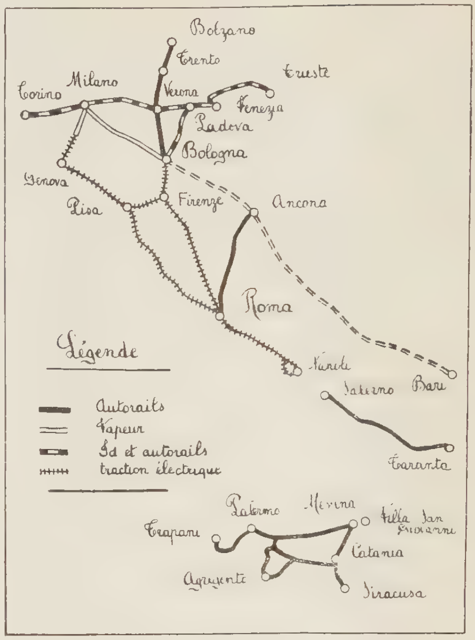

Fig. 432. — Italian « rapidi » services.

As with the former Milan-Venice high-speed steam « rapidi » which had to be decelerated, the speed of the fast railcar services that superseded them has been reduced on this non-stop run from 100 to 94.4 km. (62 to 58.65 miles) an hour and to 96.4 km. (59.9 miles) an hour on the shorter 82 km. (50.9 miles) Verona-Padua run.

The new Fiat triplet sets countain 78 seats, with a tare weight of 85 t. (83.6 Engl. tons).

7 and 8. — AUSTRIA and HUNGARY. — There are two railcar services between Vienna and Budapest (271 km. = 168.4 miles), one of which, the « Arpad », is worked by the *Royal Hungarian Rys.*, the other by the *Austrian Federal Rys.*

The former has been slightly speeded up and makes the non-stop run in 2 h. 57 m., i.e. at 91.9 km. (57.1 miles) an hour. The second, which stops five times en route, has a peculiar feature : its trailer is a through *Netherlands Rys.* coach owing to which this service gives the fastest connection between Budapest and the Hook of Holland, and beyond that with England.

(1) In addition to this mileage, 1 028 km. (639 miles) of line have runs at over 100 km. (62 miles) an hour average speed :

The P.L.M. has . . .	244 km. (151.6 miles)
The STATE	Nil.
The NORD	133 km. (82.6 miles)
The EST	158 km. (98.1 miles)
The ALSACE-LORRAINE .	88 km. (54.7 miles)
The P.O.-MIDI	405 km. (251.7 miles)

TABLE 342.

ITALIAN « RAPIDI » RAILCAR SERVICES.

Non-stop runs are shown in **heavy type**; discontinued services in *italics*.

Run.	Distance.		Time of departure.	Time spent.	Number of stops.	Speed.		Train.
	Km.	Miles.				Km./h.	M.p.h.	
Whole journey.								
Torino-Milan-Venice Mestre	420	261.0	6.40 a. m.	4.32	2	92.6	57.5	Rapido 463.
Bolzano-Verona-Bologna	261	162.2	10.45 a. m.	3.02	3	86.0	53.4	Rapido 465.
Bologna-Venice-Trieste	317	197.0	7.39 p. m.	3.41	4	86 0	53.4	Rapido 456.
Salerno-Taranto	262	162.8	8.35 p. m.	4.07	3	63.6	39 5	Rapido 103.
Fastest runs.								
Venice S.L.-Cervignano (Trieste)	112	69.6	**9.33** p. m.	**1 09**	...	**97.3**	**60.5**	Rapido 456.
Torino-Milan (Venice)	147	91.3	**6.40** a. m.	**1.31**	...	**96.9**	**60.2**	Rapido 463.
(Milan) Verona-Padova	82	51.0	**7.50** p. m.	**0.51**	...	**96.4**	**59.9**	Rapido 95.
Milan Cent.-Venice Mestre	258	160.3	**8.18** a. m.	**2 44**	...	**94.4**	**58.7**	Rapido 463.
Longest runs.								
Milan Cent.-Venice S.L.	267	165 9	*8.15 a. m.*	*2.40*	...	*100.0*	*62.0*	*Rapido 463.*
Milan Cent.-Venice Mestre	258	160.3	**8.18** a. m.	**2.44**	...	**94.4**	**58.7**	Rapido 463.
Torino P.N.-Milan Cent.	147	91.3	**6.40** a. m.	**1.31**	...	**96.9**	**60.2**	Rapido 463.
(Bolzano) Verona-Bologna	114	70.8	**12.31** p. m.	**1.16**	...	**90.0**	**55.9**	Rapido 465.
Venice S.L.-Cervignano	112	69.6	**9.33** p. m.	**1.09**	...	**97.3**	**60.5**	Rapido 456.
Rome-Terni (Ancona Mar.)	112	69.6	**8.35** p. m.	**1.17**	...	**87.3**	**54.2**	Rapido 472.

The *Györ Sopren Ebenfurth Ry. Co.* also runs fast Ganz 86-seater railcars. Negociations are proceeding with a view to the extension of this service as far as Budapest.

13. — CZECHOSLOVAKIA. — The « Blue Arrow » covers the 397 km. (246.7 miles) between Prague and Bratislava in 4 h. 20 m. with a single intermediate stop at Brno, i.e. at an overall speed of 91.3 km. (56.7 miles) an hour. The Prague-Brno 255-km. (158.5 miles) non-stop run is the longest in the country.

14. — POLAND. — Owing to the condition of the track, only the Warsaw-Lodz services are worked. The other railcar expresses are to start at some future time.

16. — DENMARK. — The original Danish « lyntogs » (lightning services) ran in the morning from Copenhagen to the provinces and returned in the evening. Since 22nd May, 1937, further lyntogs have been put on, travelling from the provinces to Copenhagen and back the same day. At the same time, certain changes have been made to the timetables (particularly in the case of the English boat train connections).

All « lyntogs » follow the same line from Copenhagen to Jutland, whence they branch off in various directions, all crossing the straits between Korsör and Nyborg, by ferryboat in 1 h. 20 m. (fig. 433), others in 1 h. 25 m. or 1 h. 30 m., embarkation and disembarkation, included.

Fig. 433. — Danish « lyntog » expresses.

The figures refer, in the same order, to the Danish ferryboat services given in table 349.

Two or more of these trains can therefore be worked at close intervals, on the same ferry. The crossing necessarily lowers the averages, in spite of the other sections being covered at high speed.

Table 343 gives additional information about these interesting services : overall journey, fastest and longest non-stop runs.

20. — GERMANY. — In the previous chapter, we mentioned the fast railcar runs (*FDt* trains). Only very slight alterations have occurred since then.

UNITED STATES OF AMERICA. — On the other side of the Atlantic, the *Atchison, Topeka and Santa Fe Ry.*'s « Super-Chief » makes the fastest run in the world. This train, which consists of ordinary coaches hauled by a diesel double locomotive, runs daily from Chicago to Los Angeles (1 386 km. = 861 miles). When it stops at Dodge City, which it does once a week only, it is allowed 145 minutes for the 326 km. (202 miles) from La Junta to Dodge City, the speed then working out at 134.6 km. (83.7 miles) an hour.

Apart from this exceptional run, the « Denver Zephyr » of the *Chicago, Burlington and Quincy Rd.* holds the record. It takes 94 minutes only between Gales and Aurora (200 km. = 124.3 miles), running at an average speed of 127.7 km. (79.2 miles) an hour. This is the fastest spurt, but the entire run of 1 664 km. (1 034 miles) from Chicago to Denver, which is made in 16 hours, is accomplished at an overall speed of 104 km. (64.6 miles) an hour.

(b) **Electric traction.** — There are more changes in England, France, Belgium and Holland where electrification is partial, than in countries like Italy, Switzerland or Austria, where it is more complete. Nonetheless, interesting services in each of these countries must be mentioned and are quoted hereafter, in the same order as previously.

1. — ENGLAND. — Nothing noteworthy save the continual extension of the *Southern Ry*'s electric system, with heavy traffic and low speeds.

2. — FRANCE. — Besides the electrification of the Paris-Bordeaux line (588 km. = 365.4 miles) which is being proceeded with and is now completed as far as Tours (238th km. = 148th mile), the *P.O.-Midi* is electrifying its Toulouse

TABLE 343.

DANISH « LYNTOG » OR LIGHTNING RAILCAR SERVICES.

Non-stop runs are shown in **heavy type.**

Name of railcar.	Run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent	Number of stops.	Speed. Km./h.	Speed. M. p. h.	—
	From COPENHAGEN to								
Vesterhavet.	Esbjerg-Ringköbing	416	258.5	7.40 a. m	6.20	13	65.7	40.8	New train.
Ostjyden.	Langaa-Struer	503	312.6	7.52 a. m.	7.20	9	68.6	42.6	Carried by same ferryboat.
Kronjyden.	Randers-Aalborg	493	306.3	8.00 a. m.	6.34	4	75.1	46.6	Do.
Englaenderen.	Esbjerg.	332	206.3	12.30 p. m.	4.25	2	75.2	46.7	English boat service.
Midtjyden.	Langaa-Struer	503	312.6	5.40 a. m.	7.27	14	67.5	41.9	New train.
Nordjyden.	Randers-Aalborg	493	306.3	5 52 a. m.	6.38	5	74.3	46.2	Carried by same ferryboat.
Nordpilen.	From PADBORG to Frederikshavn.	337	209.1	11.55 a. m.	4.45	4	71.3	44.3	Sea connection for Göteborg.
	Fastest runs.								
Vesterhavet.	Roskilde-Skagelse	61	37.9	**8.02** a. m.	**0.36**	...	**101.7**	**63.2**	...
Kronjyden.	Nyborg-Aarhus	198	123.0	**10.24** a. m.	**2.06**	...	**94.3**	**58.6**	...
Englaenderen.	Copenhagen-Korsör	110	68.3	**12.30** p. m.	**1.10**	...	**82.6**	**51.3**	The Kronjyden has the same speed.
	Longest runs. (over 100 km. - 62 miles).								
Kronjyden.	Nyborg-Aarhus	198	123.0	**10.24** a. m.	**2.06**	...	**94.3**	**58.6**	...
Nordpilen.	Kolding-Aarhus	130	80.8	**1.04** p. m.	**1.38**	...	**79.6**	**49.5**	Padborg to Frederikshavn.
Englaenderen and Kronjyden.	Copenhagen-Korsör.	110	68.3	**12.30** p. m.	**1.10**	...	**82.6**	**51.3**	...
Nordjyden.	Fredericia-Aarhus	110	68.3	**9.25** p. m.	**1.12**	...	**91.7**	**57.0**	...

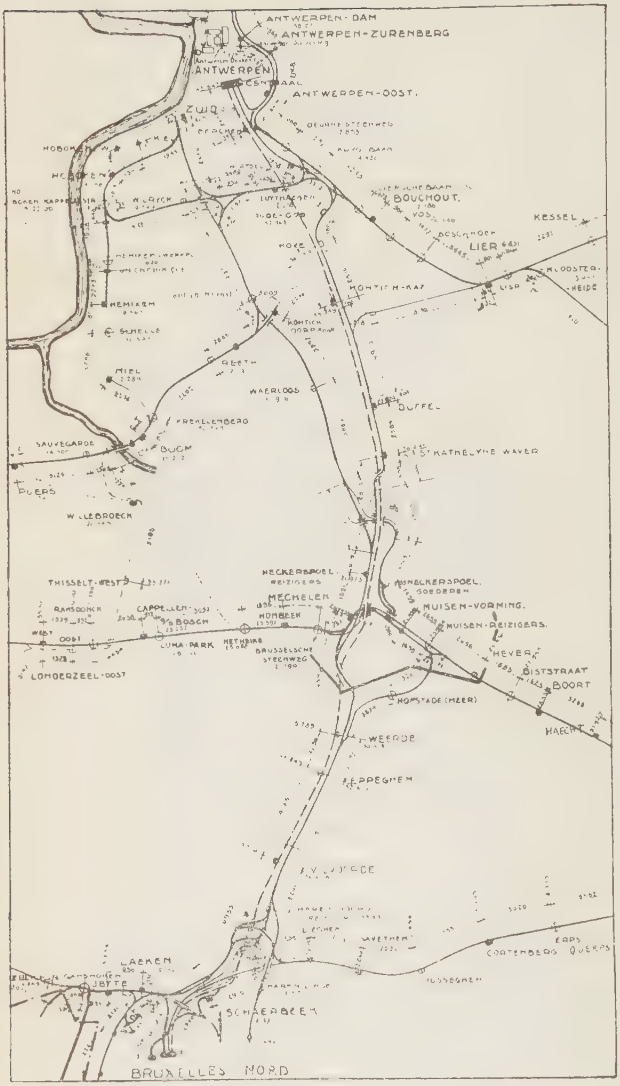

Fig. 434. — Location of the Brussels and Antwerp lines and connections with adjoining railways.

line, which branches off the former at Orleans (123th km. = 76.4th miles), and is now electrified as far as Brive-la-Gaillarde (503rd km. = 313th mile).

Although the « Sud Express » runs non-stop from Paris to Saint-Pierre-des-Corps, Tours (107.6 km. = 66.9 miles), the fastest run from Poitiers to Angoulême at 112.8 km. (70.1 miles) an hour, lies to the credit of steam locomotives. But when the optional stop at Les Aubrais (Orleans) is made, the speed as far as St-Pierre-des-Corps is 115.7 km. (71.9 miles) an hour.

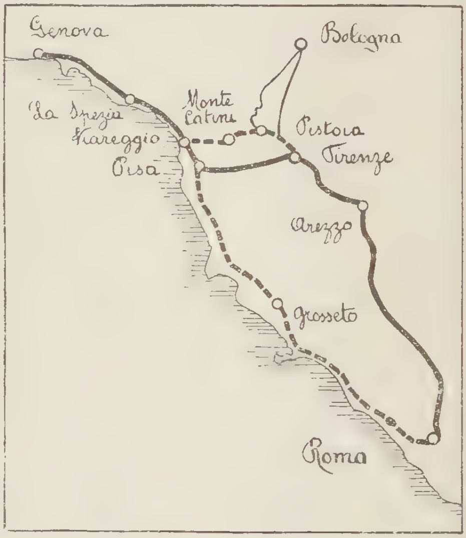

Fig. 435. — Various routes of the Genova-Rome « rapidi ».

In addition, the 400 km. (248.5 miles) from Paris to Limoges have been run non-stop since the 22nd May 1937, so that France now comes second in the list of longest non-stop runs, immediately after Italy.

Since the same date the *State* has run electric two-car sets over the 211 km. (131.1 miles) from Paris to Le Mans. Although the average speed is now 93.8 km. (58.3 miles) an hour only, it is soon to be raised to 105.5 km. (65.8 miles), the journey then being accomplished in the round two hours.

4. — BELGIUM. — When electrifying its Brussels-Antwerp line, the *Belgian National Railways Co.* improved its location, thus altering its length (1) (fig. 434). At the same time, standardised timings were introduced. The runs were none too easy, as the speed limit is 110 km. (68.3 miles) an hour for the through trains, 115 km. (71.5 miles) for those stopping at Malines, and 120 (74.6 miles) for all when running late.

6. — ITALY. — When the Bologna-Florence direttissima was electrified, a general reorganisation of the Rome services took place. On the other hand, since the economic sanctions, the Genova-Rome « rapidi » had been diverted from Pisa to Florence where they linked up with the Bologna trains, and so to Rome. This lengthened their run by 62 km. (38.5 miles). On and since the 22nd May, 1937, they have been returned to their former route. Three « rapidi » run non-stop either way between Rome and Florence (317 km. = 197 miles) and three others from Rome to Pisa via Leghorn (406 km. = 252.3 miles), this being the longest European non-stop run made by electric trains. All these runs are accomplished at around 100 km. (62 miles) an hour.

Besides express trains hauled by electric locomotives faster light motor trains have been introduced in Germany (2), Switzerland, and Italy; these consist of rakes of motor coaches and trailers known in Italy as « electrotrains ». The first of these ran from Naples to Bologna, via Rome and Florence (623 km. = 387.1 miles), the only two stops on the way. It is proposed to extend this type of service as and when other rakes are delivered.

Table 344 groups such limited trains, giving the overall speed (including stops), and the speed for each run. We have added some information about the fastest Italian runs and the longest non-stop runs of trains hauled by electric locomotives.

9. — SWITZERLAND. — Owing to the electrification of the Lucerne-Berne line via Langnau, the express railcars have been superseded by light motor coaches — the fastest in the country.

On the other hand, as from the 22nd May, 1937, the « Riviera Express » runs

(1) We tought it would be of interest to give the actual distances as well as those from Antwerp to Louvain or to Ghent, which are directly affected by the changes in location :

Brussels Nord to Antwerp Central :	
Electric line	43.827 km. (27.24 miles).
Steam line	45.500 km. (28.27 miles).
Brussels-Nord to Antwerp-East	44.490 km. (27.65 miles).
Brussels-Nord to Antwerp-South	50.425 km. (31.33 miles).
Antwerp-Louvain :	
via Wavre-Ste-Catherine	48.048 km. (29.86 miles).
via Lierre	56.927 km. (35.37 miles).
Antwerp Central to Ghent-St.-Pierre :	
via Boom	71.518 km. (44.44 miles).
via Malines	81.301 km. (50.52 miles).

(2) The fastest of them, the rail motor trains from Munich to Stuttgart, have been slowed down. Their overall speed, for the Ulm-Augsburg and Augsburg-Munich runs, has been reduced from 112.2 to 105.3 and 112.7 to 95.6 km. (69.7 to 65.4 and 70.0 to 59.4 miles) an hour.

TABLE 344.

SPEED OF ITALIAN ELECTRIC, SWISS LIGHT AND GERMAN *FDt* TRAINS.

Non-stop runs are shwon in **heavy type** and obsolete services in *italics.*

Run.	Distance.		Time of departure.	Time spent.	Number of stops.	Speed.		Class of train.
	Km.	Miles.				Km./h.	M.p.h.	
Italian electrotrains.								
Naples Merg.-Rome-Bologna	623	387.1	10.20	6.15	2	99.6	61.9	Electrotrain Rapido 24.
Naples Merg.-Rome Term.	210	130.5	R **8.08** p. m.	**1.50**	...	**114.5**	**71.1**	Do. Rapido 25.
Rome Term.-Florence Cent.	316	196.4	R **12.25** p. m.	**3 10**	...	**99.8**	**62.0**	Do. Rapido 24.
Florence-Bologna	97	60.3	R **3.50** p. m.	**0.55**	...	**105.8**	**65.7**	Do. Rapido 25.
Italy-Electric locomotives.								
FASTEST RUNS.								
Rome Term.-Leghorn	406	252.3	**5.00** p. m.	**4.06**	...	**99.0**	**61.5**	Rapido 54.
Rome Term.-Naples Cent.	214	133.0	**7.30** p. m.	**2.25**	...	**88.5**	**55.0**	Rapido 55.
LONGEST RUNS.								
Pisa-Leghorn-Rome Term.	426	264.7	**11.57** a. m.	**5.13**	...	**81.7**	**50.8**	PR Express
Leghorn-Rome Term.	406	252.3	R **5.00** p. m.	**4.06**	...	**99.0**	**61.5**	Rapido 54.
Rome Term.-Florence Cent.	316	196.4	**7.45** a. m.	**3.45**	...	**84.3**	**52.4**	Rapido 22.
Swiss light trains.								
Geneva-Berne-Zurich	287	178.3	6.33 a. m.	3.25	2	84.0	52.2	...
Geneva-Lausanne	60	37.3	**6.33** a. m.	**0.37**	...	**90.3**	**56.1**	...
Lausanne-Berne	97	60 3	**7.12** a. m.	**1.11**	...	**82.0**	**50.9**	...
Berne-Zurich	130	80.8	**8 25** a. m.	**1.33**	...	**83.9**	**52.1**	...
German FDt trains.								
Stuttgart-Munich (Berchtesgaden)	240	149.1	...	...	...	...	...	...
Stuttgart-Ulm	92	57.2	**8.32** p. m.	**1.01**	...	**90.5**	**56 2**	*FDt* 723.
Ulm-Augsburg	86	53.4	**9.34** p. m.	**0.49**	...	**105.3**	**65.4**	*FDt* 723.
Augsburg-Munich	62	38.5	**10.24** p. m.	**0.39**	...	**95.6**	**59.4**	*FDt* 720.
Munich-Freilassing (summer)	147	91.3	*R 10.09* a. m.	*1.46*	...	*86.1*	*53.7*	*FDt* 722.
Freilassing-Bad Reichenhall.	15	9.3	*8.50* p. m.	*0.15*	...	*88.0*	*54.7*	*FDt* 721.
Bad Reichenhall-Berchtesgaden	19	11.8	*9.05* p. m.	*0.38*	...	*30.6*	*19.0*	*Do.*

non-stop from Basle to Bellinzona via Olten-Aarau-Rothkreuz instead of Lucerne (fig. 436). The new route is shorter than the old, being 255 km. (158.5 miles) instead of 273 km. (163.4 miles).

Previously, on May 15th 1936, a fast service of light electric trains had been introduced upon the same principle as the Belgian « block » trains. Two sets of these run daily from Geneva to Zu-

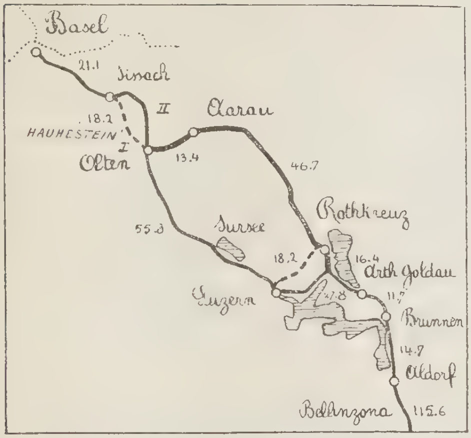

Fig. 436. — Various routes followed by the expresses from Basle to the Saint-Gothard (with the actual kilometric length of the different sections).

Heavy line : Olten-Aarau-Rothkreuz route.
Thinner line : Previous route.
Bar line : Obsolete routes.

rich and back with two intermediate stops.

A few data concerning the fastest and longest non-stop runs in the *UNITED STATES* are appended here for comparison purposes.

The fastest of these trains are not to be found on the larger systems; they are run by a high-speed interurban railway, the *Chicago-Milwaukee,* which does not even own the whole of its right of way : it runs into Chicago over the « Elevated » and into Milwaukee over the tramway's line.

The « North Shore Ltd. » takes 12 minutes to cover the 24 km. (14.9 miles) from Kenosha to Waukegan, and 7 minutes for the 14 km. (8.7 miles) from Zion to Kenosha. It therefore markedly exceeds the 111 km. (69 miles) an hour of the *Pennsylvania Rd*'s fastest train.

As shown by table 345 there are but three European countries, Germany, France and Italy, where the average speed exceeds 100 k. (62 miles) an hour, and three, Switzerland, Belgium and Holland, where it is over 90 km. (56 miles). Three others have average speeds exceeding 80 km. (50 miles).

(c) **Steam traction.** — Average speeds exceeding 106 km. (65.9 miles) an hour, are to be found in four European countries, England, France, Belgium and Germany and over 90 km. (56 miles) an hour, in four others.

1. — ENGLAND. — The « Cheltenham Flyer » *(Great Western Ry.)* was the first train timed at over 70 miles (112.65 km.) an hour. Though this only dates from 1932, less than 4 years have sufficed to the establishment of 11 faster trains, if all kinds of traction are taken into account.

Amongst the newer trains, the same Railway's « Bristolian » runs over the same line. It takes, both up (which is the better performance) and down, 105 minutes to cover the 190 km. (118.25 miles) between London and Bristol, so that the average speed is 108.6 km. (67.5 miles) an hour. The « Cornishman » which duplicated the « Cornish Riviera Ltd. » was short-lived.

The *London & North Eastern Ry.*, introduced the « East Anglian », this summer, and the « Silver Jubilee », both with streamlined locomotives, the latter running between London and Darlington at almost the same speed as the « Cheltenham Flyer », the fastest train in the country, and just a little faster than the « Sud Express », the fastest French steam train.

If there is little to be said as regards fast runs, this does not apply to non-stop runs, in which England still leads.

The « Flying Scotsman » covers the 631 km. (392.1 miles) non-stop from

Table 345.

FASTEST AND LONGEST RUNS IN THE DIFFERENT COUNTRIES OF EUROPE. — ELECTRIC TRACTION.

Non-stop runs in **heavy type**; American runs in *italics*.

Serial number.	Country.	Railway.	Run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. M.p.h.	Name and class of train.
			Fastest runs.							
...	*U.S.A.*	*Chic. & N. Shore.*	*Kenosha Waukegan.*	*25*	15.5	*3.42* p. m.	*0.12*	*121.0*	*75.0*	*The North Shore Ltd.*
1	France.	P.O. Midi.	(Paris) Les Aubrais (1)-St. Pierre des Corps.	112(3)	69.6(3)	12.43 p. m.	0.58	115.7	71.9	Sud Express.
2	Italy.	State.	Rome Term.-Naples Merg. . .	210	130.5	8.00 p. m.	1.50	114.5	71.1	« Electrotrain ».
3	Germany.	Reichsbahn.	Ulm-Augsburg (Munich) . .	86	53.4	9.34 p. m.	0.49	105.3	65.4	Electric motor coach train
4	Switzerland.	Federal Rys.	Geneva-Lausanne (Zurich). .	60	37.3	6.33 a. m.	0.37	97.3	60.5	Limited light train.
5	Belgium.	Nat. Rys. Co.	Brussels N.-Antwerp Central .	45	28.0	**frequent**	0 29	93.1	57.8	...
6	Netherlands.	Netherlands.	Leiden-Haarlem	29	18.0	10.10 p. m.	0.19	91.6	56.9	...
7	Hungary.	State.	(Budapest) Györ-Hegyeshalom.	46	28.6	9.22 a. m.	0 32	86.3	53.6	Arlberg-Orient Express.
8	Sweden.	Do.	(Stockholm) Nässjö-Alvesta .	87	54.1	2.29 a. m.	1.01	85.6	53.2	...
9	Gr. Britain.	Southern Ry.	London Vict.-Brighton . . .	82	51.0	11.00 a. m.	0.38	85.0	52.8	Many trains.
10	Austria.	Federal Rys.	Innsbrück-Wörgl-(Salzburg) .	49	30.4	1.15 p. m.	0.49	73.4	45.6	...
11	Norway.	State.	Oslo-Drammen	53	32.9	11.00 p. m.	0 56	56.8	35.3	Including 1 optional stop.
			Longest runs.							
1	Italy.	State.	Pisa-Rome Term.	426	26.5	11.57 a. m.	5.13	81.7	50.8	Paris-Rome Express.
2	France.	P.O. Midi.	Paris Aust-Limoges	400(2)	248.6(2)	8.30 p. m.	4 08	96.7	60.1	Barcelona Express.
	Do.	State.	Paris Mp.-Le Mans	211	131.1	8.00 a. m.	2.15	93.8	58.3	Introduced in June 1937.
3	Switzerland.	Federal Rys.	Basle-Bellinzona.	255	158.5	1.08 a. m.	3.41	69.2	43.0	Riviera Express.
4	Germany.	Reichsbahn.	Munich-Stuttgart (Kehl) . .	221	137.3	10.10 p. m.	2.47	79.4	49.3	Orient Express.
5	Sweden.	State.	Bollnas-Ange	167	103.8	12.24 a. m.	2.05	80.1	49.8	...
6	Hungary.	Do.	Budapest Keleti-Györ. . . .	130	80 8	7.46 a. m.	1.35	82.1	51.1	Arlberg-Orient Express.
7	Austria.	Federal Rys.	Inssbrück-Kitzbühel	95	59.0	11.25 a. m.	1.22	70.0	43.5	...
8	Netherlands.	Netherlands.	Haarlem-The Hague	44	27.3	9.54 p. m.	0.34	77.7	48.3	...

(1) These runs include optional stops, one at Les Aubrais and the other during the run.

(2) The accurate distance which is 399.6 km. (248.3 miles). differs from the Chaix Timetables.

(3) Exact distance, 111.8 km. (69.46 miles).

TABLE 346a.

FASTEST RUNS IN EACH EUROPEAN COUNTRY. — STEAM TRACTION.

Serial number.	Country.	Railway.	RUN.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. M.p.h.	Name or class of train.
	U.S.A.	*Pennsylvania.*	*Fort Wayne-Gary*	198	123.0	*6.00* p. m.	*1.39*	*119.9*	*74.5*	*The Detroit Arrow.*
1	Germany.	Reichsbahn.	Berlin Lehrter Bhf.-Hamburg	287	178 3	6.13 p. m.	2.24	119.6	74.3	...
	Do.	Lübeck-Büchen.	Hamburg-Lübeck	63	39.1	1.11 p. m.	0.40	94.5	58.7	...
2	Gr.-Britain.	L. & N. E. Ry.	*London (K's Cr.)-York*	303	188.3	*4.00* p. m.	*2.37*	*115.7*	*72.1*	*The Coronation* (July 1937).
	Do.	Great Western.	Swindon-London Padd.	124	77.0	3.55 p. m.	1.05	114.9	71.4	The Cheltenham Flyer.
	Do.	L. & N. E. Ry.	London K's Cross-Darlington	374	232.0	5.30 p. m.	3.18	114.3	70.4	The Silver Jubilee.
	Do.	L.M. & S. Ry.	Rugby-Watford Jn. (Euston)	105	65.1	6 58 p. m.	1.00	104.8	65.1	...
	Do.	Southern Ry.	London (Wat.)-Salisbury	135	83.9	11.00 a. m.	1.27	92.2	57.9	The Atlantic Coast Express.
3	France.	P.O. Midi.	(Paris) Poitiers-Angoulême.	113	70.2	2.45 p. m.	1.00	112.8	70.1	The Sud Express.
	Do.	P.L.M.	(Paris) Valence-Avignon.	124	77.0	4.36 p. m.	1.08	109.1	67.8	Streamlined train.
	Do.	Nord.	Paris N.-St. Quentin (Liége)	153	95.1	1.35 p. m.	1.28	104.3	64.7	...
	Do.	Alsace-Lorraine.	Metz-Strasbourg (Basle) (1)	155	96.3	2.57 p. m.	1.30	103.3	64.2	The Edelweiss.
	Do.	Est.	Paris E.-Troyes	167	103.8	7.10 a. m	1.37	102.6	63.8	...
	Do.	State.	Paris St. Laz.-Rouen (Havre).	140	87.0	8.15 a. m.	1.26	101.2	62.9	...
4	Belgium.	B. Nat. Rys. Co.	Ostend Quay-Brussels Midi.	114	70.8	7.04 p. m.	1.04	106.9	66.4	...
5	Poland.	State.	(Warsaw) Poznan-Zbaszyn	75	46.6	4.46 p. m.	0.48	93.7	58.2	The Nord Express.
6	Ireland.	Great Northern.	Dublin-Drogheda.	52	32.3	6.40 a. m.	0.33	93.6	58.1	...
7	Portugal.	Portug. Rys. Co.	Lisbon-Entroncamento	113	70 2	2.10 p. m.	1.10	92.9	57 7	The Sud Express.
8	Denmark.	State.	Padborg Fredericia.	110	68.3	12 49 a. m.	1.12	91.7	57.0	...
9	Spain.	Norte.	(Madrid) Venta de Banos-Burgos.	85	52 8	2 49 p. m.	0.56	90.0	55.9	...
	Do.	M.Z.A.	Alcazar de San Juan-Albacete.	130	80.8	1.39 a. m.	2.00	75.0	46.6	...
10	Czechoslovakia.	State.	Chocen-Pardubice	34	21.1	8.13 a. m.	0.23	88.9	55.2	...
11	Italy.	Do.	Bologna-Piacenza (Milan)	147	91.3	1 59 p. m.	1.41	87.3	54.2	...
12	Netherlands.	Netherlands.	Roosendaal-Flushing	75	46.6	12.43 p. m.	0.54	83.3	51.8	Boat train.
13	Rumania.	State.	Bucharest-Ciulnita (Constanza)	114	70.8	1.40 p. m.	1.22	83.1	51.6	The Simplon Express.
14	Hungary.	Do.	Budapest Keleti-Ujszasz (Szolnok).	84	52.2	12.40 p. m.	1.01	82.6	51.3	...
15	Austria.	Federal.	(Vienna) St. Pölten-Linz	128	79.5	4.10 p m.	1.33	82.6	51 3	...
16	Sweden.	Bergslagernas.	(Oslo) Mellerud-Oxnered.	41	25.5	2 08 p. m.	0 32	76.9	47.8	...
17	Jugoslavia.	State.	Slavonski Brod-Vinkovci.	65	40.4	3 41 a. m.	0.54	72.3	44.9	The Simplon-Orient Express.
18	Finland.	Do.	Rihimäki-Helsinki	71	44.1	9.08 p. m.	1.00	71.0	44.1	...
19	Norway.	Do.	(Oslo O.) Eidsvol-Hamar	58	36.0	10.28 p. m.	0.59	59.0	36.7	...

(1) The distance from Strasburg to Metz is 155 km. (96.3 miles) via Reding-Spur and 158 km. (98.2 miles) via Sarrebourg. That from Metz to Luxembourg is 62 km. (38.5 miles).

TABLE 346*b*.

LONGEST STEAM WORKED RUNS IN EACH EUROPEAN COUNTRY.

Non-stop runs in **heavy type.**

Serial number.	Country.	Railway.	Run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. M.p.h.	Name or class of train.
1	Gr. Britain.	L. and N.E.Ry.	London (K's Cross)-Edinburgh	631	392.1	10.00 a. m.	7.00	90.1	56.0	The Flying Scotsman.
	Do.	L.M. and S. Ry.	London (Euston)-Kingmoor .	484	300.7	10.00 a. m.	5.22	90.0	55.9	The Royal Scot.
	Do.	Do.	London-Carlisle (July 1937) .	481	298.9	*1.30 p. m.*	*4.43*	*102.0*	*63.4*	*The Coronation Scot.*
	Do.	Great Western.	London (Padd.)-Plymouth . .	364	226.2	10.30 a. m.	4.00	90.6	56.3	The Cornish Riviera.
	Do.	Southern Ry.	London (Wat.)-Bournemouth .	174	108.1	4.30 p. m.	1.54	91.4	56.8	The Bournemouth Ltd. Express.
2	Fr.+Belgium.	Nord + Belg. N. R. Co.	Paris Nord-Liége Guillemins .	403	250.4	7.15 p. m.	3.56	101.4	63.0	The Nord Express.
	France.	Est.	(Strasbourg) Nancy-Paris . .	353	219.3	9.09 a. m.	3.31	100.3	62.3	...
	Do.	Nord.	Paris N.-Dunkirk Town . . .	305(1)	189.5(1)	9.50 p. m.	3.22	90.5	56.2	Ferryboat train.
	Do.	State.	Paris Mp.-Saumur (Royan) .	286	177.7	12.04 p. m.	3.27	82.9	51.5	The Paris-Royan Rapide.
	Do.	P.L.M.	(Paris P.L.M.) Dijon-Lyons Perrache.	197	122.4	3.15 p. m.	1.59	99.3	61.7	Streamlined train.
	Do.	Alsace-Lorraine.	Metz-Strasbourg (Basle). . .	155	96.3	2.57 p. m.	1.30	103.3	64.2	The Edelweiss.
	Do.	P.O. Midi.	Bordeaux-Angoulême (Paris) .	134(2)	83.3(2)	2.28 p. m.	1.24	95.7	59 5	The Sud Express.
3	Germany.	Reichsbahn.	(Berlin Anh.) Halle-Nuremberg	314	195.1	12.05 p. m.	4.10	75.4	46.9	...
	Do.	Lübeck-Büchen.	Hamburg-Lübeck-Travemünde .	83	51.6	6.35 a. m.	1.27	57.0	35.4	...
4	Italy.	State.	Milan Cent.-Bologna	219	136 1	2.50 p. m.	2.38	83.1	51.6	...
5	Finland.	State.	(Abo) Turko-Helsinki (summer)	200	124.3	11.15 a. m.	3.27	57.9	36.0	...
6	Spain.	M.Z.A.	Saragossa Sep.-Mora la Nueva	191	118.7	3.50 a. m.	3.13	60.0	37.3	Company's « de luxe » train.
7	Austria.	Federal.	Linz-Vienna West	189	117.4	11.42 a. m.	2.22	80.0	49.7	The Arlberg-Orient Exp.
8	Poland.	State.	Byalistock-Warsaw.	179	111.2	10.38 a. m.	2.07	84.6	52.6	The Nord Express.
9	Belgium.	Belg. N. R. Co.	Luxembourg-Namur (Brussels).	164	101.9	1.25 p. m.	1.54	86.3	53.6	The Edelweiss.
10	Czechoslovakia.	State.	Prague M.-Ceska Trebova . .	164	101.9	R 2.42 p. m.	2.13	74.0	46 0	...
11	Netherlands.	Netherlands.	Flushing-Eindhoven	157	97.6	6.15 p. m.	2.00	78.5	48.8	Boat train.
12	Sweden.	State.	Bräcke-Längsele	131	81.4	3.15 a. m.	1.50	70.4	43.7	...
13	Denmark.	Do.	Masnedö-Nestved-Ringsted . .	122	75.8	5.10 a. m.	1.41	72.4	45.0	...
14	Norway.	Do.	Gol-Hönefoss (Oslo)	113	70.2	3.06 a. m.	2.86	54.0	33.6	...
15	Jugoslavia.	Do.	(Belgrade) Novska Dugo Selo Zagreb	118	73.3	4.00 a. m.	1.40	70.8	44.0	...
16	Ireland.	Great Northern.	Dublin-Belfast	116	72.1	2.55 p. m.	1.21	78.2	48.6	...
17	Portugal.	Portug. Rys. Co.	Lisbon-Entroncamento. . . .	113	70.2	2.10 p. m.	1.10	92.9	57.7	The Sud Express.
18	Rumania.	State.	Bucharest N.-Ciulnita. . . .	114	70.8	1.40 p. m.	1.22	83.1	51.6	...
19	Hungary.	Do.	Szolnok-Budapest Keleti. . .	100	62.1	6.00 p. m.	1.34	80 0	49.7	...

(1) Exact distance (the Chaix Timetables give the tariff distances) from Paris to Dunkirk, 304 800 m. (189.4 miles).

(2) The real distance is 134.4 km. (83.5 miles). The distance for tariff purposes, of 139 km. (86.4 miles), includes an addition for the Bordeaux bridge which is nearly 500 m. (1 640') long.

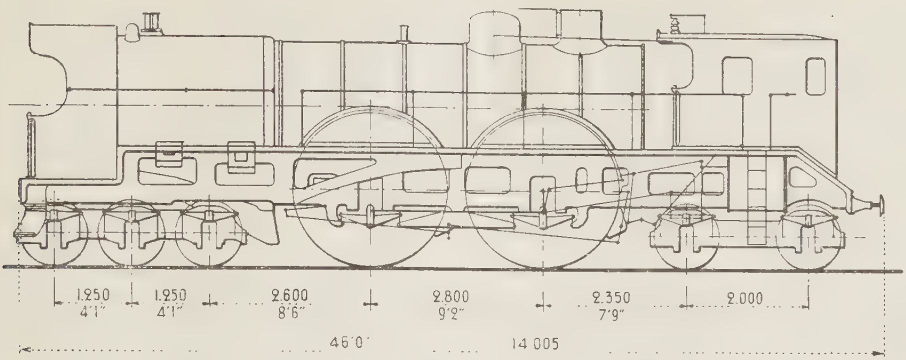

Fig. 437. — *Thuile* locomotive built by the Creusot Works.

London (King's Cross) to Edinburgh in 7 hours instead of the former 7 1/2 h. Since July, 1937, a new train, the « Coronation » takes only 6 hours, maintaining over the whole run and in spite of stopping at York on the return and at Newcastle on the outward journey, an average speed of 105.1 km. (65.3 miles) an hour. The London-York section (188.2 miles at 71.9 miles an hour) is the fastest British run. The West Coast's competitive train, the « Coronation Scot » runs from London (Euston) to Glasgow in 6 h. 30 m. with a stop at Carlisle, the first section of 481 km. (298.9 miles) being covered at 102 km. (63.4 miles) an hour.

2. — FRANCE. — The streamlined locomotive test carried out by the main-line Railways foreshadow further speeding-up. Up to the present, the ***P.L.M.*** alone operated a completely streamlined train, running it between Paris and Lyons, and since the 22nd May 1937, on to Marseilles. It covers the 863 km. (536.3 miles) down to this place, with 5 intermediate stops at one of which locomotives are changed, in 9 hours. This works out at an average of 95.9 km. (59.6 miles) an hour.

All this takes the French railways far ahead of the *Heilmann* and of the *Thuile locomotive* (fig. 437), built in 1900 by the Creusot Works [1].

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[1] Its leading dimensions were :

Wheels, diameter	2.50 m. (8' 2 7/16"). 1.06 m. (3' 6").
Wheelbase	12.25 m. (40' 2 9/32").
Cylinders { bore	0.51 m. (20 1/16").
Cylinders { stroke	0.70 m. (27 1/2").
Grate area	4.68 m² (50.6 sq. ft.).
Heating surface (boiler)	297.7 m² (3 203 sq. ft.).
Overall length	14.005 m. (45' 11 25/64").
Width	2.80 m. (9' 2 1/4").
Maximum height	4.22 m. (13' 10 5/32").
Tractive power (0.65)	7 100 kgr. (15 650 lb.).
Weight empty	72 t. (70.8 Engl. tons).
Weight in working order	80.6 t. (79.3 Engl. tons).

The long Franco-Belgian or French non-stop runs are unaltered : Paris-Liége (403 km. = 250.4 miles); Paris-Brussels (311 km. = 193.3 miles), and in France only, Paris-Nancy (353 km. = 219.4 miles). Some of them have been speeded up; the Paris-Liége run takes 3 h. 56 m., at an average speed of 101.9 km. (63.3 miles) an hour, while the « Oiseau Bleu » runs non-stop from Paris-Nord to Brussels-Midi in the round 3 hours, at 103.5 km. (64.3 miles) an hour. The *Est Ry.*'s 353 km. (219.3 miles) run is the longest purely French non-stop one. Since the introduction of the new London-Paris train-ferry service, the *Nord Ry.* has re-established non-stop Paris and Dunkirk runs (305 km. = 189.5 miles) in 3 h. 22 m., but at a lower average speed, which is 90.6 km. (56.3 miles) an hour only.

4. — BELGIUM. — Beginning with the 1936/37 winter timetables, certain Brussels-Ostend expresses henceforward stopped at Ghent and at the same time started from the Nord instead of the Midi station, which increased the distance by 2 km. (1.2 miles), without any extra time being added to the 67 minutes alloted them. As they used the Bruges Saint-André new by-pass, distances altered to some extent [1]. As the trains only had 34 minutes for the Ghent-Ostend run, the average speed between these places reached, for the first time in Belgium, 109.2 km. (67.8 miles) an hour. This gave Belgium fourth place before two of the English main-line railways, the *L.M.S.* and the *Southern*. The shortest time taken for the Brussels-Ostend non-stop run is 1 h. 4 m.

20. — GERMANY. — We have mentioned the remarkable Berlin-Hamburg service [1] worked at 119.6 km. (74.3 miles) an hour, which brings Germany to the top of the European list, before the *Great Western* and *L.N.E. Rys.* in *England*, the *P.O.-Midi* in France, and the *Belgian National Rys. Co.* in Belgium. Five other countries, Poland, Ireland, Denmark, Portugal and Spain run trains at average speeds of 90 to 100 km. (56 and 62 miles) an hour.

But even Germany is out-paced — though only just so — by the « Detroit Arrow » of the *Pennsylvania Rd.*, whose average speed exceeds its own by the small margin of 300 m. (984 feet) an hour.

(d) **Apportionment of the fastest speeds and longest non-stop runs between the various kinds of traction.** — Table 347 summarises the previous tables and shows each railway's fastest and longest non-stop runs of each kind. This table is in fact the synthesis of all the previous articles in this series.

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(1) When the Bruges by-pass is used the distances from Brussels to Ghent and Blankenberghe are as follows :

Brussels-Midi to Ghent-St. P.	52.115 km. (32.37 miles).
Brussels-Nord to Ghent-St. P.	54.295 km. (33.74 miles).
Ghent-St. P. to Ostend-Quay (through) . . .	61.880 km. (38.46 miles).
Ghent-St. P. to Ostend-Quay (via Bruges-Town)	62.580 km. (38.88 miles).
Ghent-St. P. to Blankenberghe (through) . .	55.564 km. (34.52 miles).
Ghent-St. P. to Blankenberghe (via Bruges-Town)	55.340 km. (34.39 miles).
Ghent-St. P. to Bruges-St. André	40.680 km. (25.28 miles).
Bruges-St. André to Ostend-Quay	21.200 km. (13.17 miles).

(1) See *Bulletin*, October 1937, pages 2027 et seq.

FASTEST AND LONGEST RUNS IN EACH EUROPEAN COUNTRY AND METHOD OF TRACTION USED IN EACH CASE.

Serial number.	Country.	Railway.	Run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. M.p.h.	Method of traction.	Name of train.
			Fastest runs.								
1	Germany.	Reichsbahn.	(Berlin) Hanover-Hamm	177	110.0	9.19 p. m.	1.20	137.9	85.7	Railcar.	...
...	*U.S.A.*	*Santa Fe.*	*La Junta-Dodge City.*	*326*	202.6	...	*2 25*	*134.7*	*83.7*	*Do.*	*The Super Chief.*
2	France.	P.L.M.	(Paris) Laroche-Dijon	159	98.8	9.29 a. m.	1.22	116.4	72.4	Do.	...
...	Do.	Nord.	Paris-Longueau (Lille)	126	78.3	10.25 a. m.	1.05	116.3	72.3	Do.	Several times daily.
3	Gr. Britain.	*L. & N. E. Ry.*	*London (K's Cross)-York.*	303	188.3	*4.00* p. m.	*2.37*	*115.7*	*71.9*	*Steam.*	*The Coronation.*
...	Do.	Great Western.	Swindon-London (Padd.).	124	77.1	3.55 p. m.	1.05	114.9	71.4	Do.	The Cheltenham Flyer.
4	Italy.	State.	Rome Term.-Naples Merg.	210	130.5	8.00 p. m.	1.50	114.5	71.1	Electric.	« Electrotrain ».
5	Belgium.	B. N. Rys. Co.	Ostend-Brussels Midi.	114	70.8	7.04 p. m.	1.04	106.9	66 4	Steam.	...
6	Denmark.	State.	Roskilde-Skagelse	61	37.9	8.02 a m.	0.36	101.7	63.2	Railcar.	The Vesterhavet.
7	Switzerland.	Federal.	Geneva-Lausanne (Zurich).	60	37.3	6.33 a. m.	0.37	97.3	60.5	Electric.	Limited light train.
8	Czechoslovakia.	State.	(Prague) Brno-Bratislava	142	88.2	9.27 p. m.	1.28	96.8	60.2	Railcar.	The Blue Arrow.
9	Poland.	Do.	Warsaw Gl.-Lodz Fab.	130	80.8	10.25 a. m.	1.23	95.5	59.3	Do.	3 services daily.
10	Ireland.	Great Northern.	Dublin-Drogheda	52	32.3	6.40 a. m.	0.33	93.6	58.2	Steam.	...
11	Portugal.	Portug. Rys. Co.	Lisbon-Entroncamento	113	70.2	2.10 p. m.	1.10	92.9	57.7	Do.	The Sud Express.
12	Hung.+Austr.	State + Federal.	Budapest-Kel. Vienna W.	271	168.4	7.10 a. m.	2.57	91.9	57.1	Railcar.	The Arpad.
13	Netherlands.	Netherlands.	Leiden-Haarlem.	29	18.0	10.10 p. m.	0.19	91.6	56.9	Electric.	...
14	Spain.	Norte.	(Madrid) V. de Banhos-Burgos	85	52.8	2.49 p. m.	0.56	90.0	55.9	Steam.	...
15	Sweden.	State.	(Stockholm) Nässjö-Alvesta	86	53.4	12.35 p. m.	1.01	85.6	53.2	Electric.	...
16	Rumania.	Do.	Bucharest-Ciulnita (Constanza	114	70.8	1.40 p. m.	1.22	83.1	51.6	Steam.	The Simplon Orient Ex.
17	Austria.	Federal.	(Vienna) St. Pölten-Linz	128	79.5	4.10 p. m.	1.33	82.6	51.3	Do.	...
18	Jugoslavia.	State.	Slavonski Brod-Vinkovci	65	40 4	3.41 a. m.	0.54	82.3	51.1	Do.	The Simplon Orient Ex.
19	Finland.	Do.	Rihimäki-Helsinki	71	44 1	9.08 p. m.	1.00	71.8	44.6	Do.	...
20	Norway.	Do.	(Oslo O.) Eidsvol-Hamar	58	36.0	10.28 p. m.	0.59	59.0	36.7	Do.	...
			Longest runs.								
1	Gr. Britain.	L. & N. E. Ry.	London (Kg.'s Cross)-Edinburgh.	631	392.7	4.30 p. m.	7.00	90.1	56.0	Steam.	The Flying Scotsman.
2	Italy.	State.	Pisa-Rome Term.	426	264.7	11.57 a. m.	5.13	81.7	50.8	Electric.	The Paris-Rome Expr.
...	Fr.+Belg.	Nord + B. N. Rys. Co.	Paris-Liége Guill.	403	250.4	6.15 p. m.	3.56	101.9	63.3	Steam.	The Nord Express.
3	France.	P.O. Midi.	Paris Aust.-Limoges	400	248.6	8.30 p. m.	4.08	96.7	60.1	Electric.	The Barcelone Express.
4	Germany.	Reichsbahn.	(Berlin) Leipzig-Nuremberg	322	200.1	6.09 p. m.	3.43	95.3	59.2	Railcar.	...
5	Hung.+Austr.	State + Federal.	Budapest Keleti-Vienna.	271	168.4	7.10 a. m.	2.57	81.9	50.9	Do.	The Arpad.
6	Czechoslovakia.	State.	Prague Wils.-Brno.	255	158.4	6.35 p. m.	2.49	90.5	56.2	Do.	The Blue Arrow.
7	Switzerland.	Federal.	Basle-Bellinzona	255	158.4	1.08 a. m.	3.41	69.2	43.0	Electric.	The Riviera Express.
8	Denmark.	State.	(Copenhagen) Nyborg-Aarhus	198	123.0	10 24 a. m.	2.06	94.3	58.6	Railcar.	The Kronjyden.
9	Spain.	M.Z.A.	Saragossa-Mora la Nueva	191	118.7	3.50 a. m.	3.13	60.0	37.3	Steam.	Company's «de luxe» train.
10	Austria.	Federal.	Linz-Vienna West	189	117.4	11.42 a. m.	2.24	78.7	48 9	Do.	The Arlberg-Orient Exp.
11	Poland.	State.	Byalistock-Warsaw	179	111.2	10.38 a. m.	2.07	84.6	52.6	Do.	The Nord Express.
12	Sweden.	Do.	Bollnas-Ange.	167	103.8	12 24 a. m.	2.05	80.1	49.8	Do.	...
13	Belgium.	B. N. Rys. Co.	Luxembourg-Namur (Brussels).	164	101.9	1.25 p. m.	1.54	86.3	53.6	Do.	The Edelweiss.
14	Netherlands.	Netherlands.	Flushing-Eindhoven	157	97.6	6.15 p. m.	2.00	78.5	48.8	Do.	Boat train.
15	Hungary.	State.	Budapest Kel.-Györ	130	80.8	7.46 a. m.	1.35	82.1	51 0	Electric.	The Arlberg-Orient Exp.
16	Jugoslavia.	Do.	Novska Dugo Selo-Zagreb	118	73.3	4.00 a. m.	1.40	70.8	44.0	Steam.	Simplon-Orient Express.

TABLE 348.

FASTEST AND LONGEST NON-STOP RUNS MADE BY THE CRACK TRAIN OF EACH OF THE FRENCH AND BRITISH MAIN-LINE COMPANIES, SHOWING THE METHOD OF TRACTION USED IN EACH CASE.

Runs over lines belonging to other Administrations are inserted in *italics* at their proper place as regards speed or distance covered.

Serial number.	Country.	Railway.	Run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. M.p.h.	Method of traction.	Name of train.
			Fastest runs.								
...	*Germany.*	*Reichsbahn.*	*Hamm-Hanover* . . .	*177*	*110.0*	*9.19* p. m.	*1.20*	*137.0*	*85.1*	*Railcar.*	...
1	France.	P.L.M.	(Paris) Laroche-Dijon .	159	98.8	9.29 a. m.	1.22	116.4	72.4	Do.	...
2	Do.	Nord.	Paris Nord-Longueau. .	126	78.3	10.25 a. m.	1.05	116.3	72.3	Do.	...
3	Do.	State.	Paris St. Lazare-Havre .	228	141.7	8.05 a. m.	1.58	115.9	72.0	Do.	...
4	Do.	P.O. Midi.	Les Aubrais-St. Pierre des Corps	112	69.6	12.43 p. m.	0.58	115.7	71.9	Electric.	The Sud Express.
5	England.	L. & N.E. Ry.	London (K's Cross)-York	303	*188.3*	*4.30* p. m.	*2.37*	*115.7*	*71.9*	*Steam.*	*The Coronation.*
6	Do.	Great Western.	Swindon-London Paddington.	124	77.0	3.55 p. m	1.05	114.9	71.4	Do.	The Cheltenham Flyer.
...	*Italy.*	*State.*	*Rome Term.-Napl. Merg.*	*210*	*130.5*	*8.00* p. m.	*1.50*	*114.5*	*71.1*	*Electric.*	« Electrotrain ».
...	England.	L. & N.E. Ry.	London (K's Cross)-Darling.	374	232.4	5.30 p. m.	3.18	114.3	71.0	Steam.	The Silver Jubilee.
7	France.	Est.	Paris E.-Bar le Duc . .	254	157.8	7.50 p. m.	2.14	113.9	70.8	Railcar.	...
8	Do.	Alsace-Lorr.	Strasbourg-Nancy . . .	150	93.2	6.00 a. m.	1.20	112.5	69.9	Do.	...
...	*Belgium.*	*B. Nat. Rys. Co.*	*Ghent-Ostend* (winter) .	62	38.5	9.11 a. m.	0.34	109.2	67.8	Steam.	...
9	England.	L.M. & S. Ry.	Rugby-Watford Jn. . .	105	65.2	6.58 p. m.	1.00	104.8	65.1	Do.	...
10	Do.	Southern Ry.	London Wat.-Salisbury .	135	83.9	11.00 a. m.	1.27	92.2	57.3	Do.	The Atlantic Coast Exp.
			Longest runs.								
1	England.	L. & N.E. Ry.	London (Kg's Cross)-Edinb.	631	392.1	10.00 a. m.	7.00	90.1	56.0	Steam.	The Flying Scotsman.
2	Do.	L.M. & S. Ry.	London (Eust.)-Kingm. .	484	300.7	10 00 a. m.	5.22	90.0	55 9	Do.	The Royal Scot.
...	*Italy.*	*State.*	*Pisa-Rome Term.* . . .	*426*	*264.7*	*11.57* a. m.	*5.13*	*81.7*	*50.8*	*Electric.*	The Paris-Rome Expr.
3	France-Belg.	Nord.	Paris N.-Liége Guillem.	403	250.4	7.15 p. m.	3.56	101.4	63.0	Steam.	The Nord Express.
4	France.	P.O. Midi.	Paris Aust.-Limoges . .	400	248 5	8.30 p. m.	4.08	96.7	60.1	Electric.	The Barcelona Express.
5	England.	Great Western.	London Padd.-Plymouth.	364	226.2	12.50 p. m.	4.00	91.0	56.5	Steam.	The Cornish Riviera Ex.
6	France.	Est.	Nancy-Paris	353	219.3	9.09 a. m.	3.31	100.3	62.3	Do.	...
...	*Germany.*	*Reichsbahn.*	*Leipzig-Nuremberg.* . .	*322*	*200.1*	*6.27* p. m.	*3.25*	*94.2*	*58.5*	*Railcar.*	...
7	France.	State.	Paris Mp.-Saumur. . .	286	177.7	12.04 p. m.	3.27	82.9	51 5	Steam.	Paris-Royan Rapide.
...	*Various.*	*Various.*	...	...	...	...	...	...	...	...	...
8	France.	P.L.M.	Dijon-Lyons Perr. . . .	197	122.4	10.54 a. m.	1.45	112.6	70.0	Railcar.	...
...	...	...	Do.	Do.	Do.	3.15 p. m.	1.59	99.3	61.7	Steam.	...
9	England.	Southern Ry.	London Wat.-Bournem. .	174	108.1	4.30 p. m.	1.54	91.4	57.0	Do.	Atlantic Coast Express.
10	France.	Alsace-Lorr.	Metz-Strasbourg . . .	155	96.3	2.58 p. m.	1.29	104.5	64.9	Do.	The Edelweiss.

If we exclude European countries, it will be seen that in the six countries with average speeds exceeding 100 km. (62 miles) an hour, the fastest run is made in three cases (Germany, France and Denmark) by railcars, in two cases by steam traction (England and Belgium), and in one only (Italy) by electric traction.

Out of the twenty countries dealt with, the leading place is held in 9 cases by steam trains, and in the remainder, in 6 cases by railcars, and in 5, by electric trains.

If we now consider the longest non-stop runs, dealing at first only with the seven countries with non-stop runs exceeding 200 km. (124.5 miles) in length, steam traction holds the first and third places (Great Britain and France-Belgium), electric the second and seventh (Italy and Switzerland) and railcars the fourth, fifth and sixth (Germany, Hungary-Austria, and Czechoslovakia). Taken as a whole, among the 16 countries mentioned, 9 places go to steam, 3 to electricity and 4 to railcars.

The British main-line and French Companies are autonomous units and just as distinct from each other as two railways operated by different States. That is why it is necessary to give the same information as above for each of these main-line railways (see Table 348).

CHAPTER LX.

The services.

LX-1. — **Recent modifications** concern, in particular, the standardisation of the timetables and the increasing number of fast internal services. But, however convenient standard timetables may be, they are difficult to draw up, the more so the heavier the traffic, and it is unluckily on such heavily loaded lines that these timings are of greatest use.

They originated in England, and their use spread to Holland (electric and diesel trains), and to certain French lines. The *State Rys.* applied them on the Paris to Trouville-Deauville and next to the Paris-Havre 228-km. (141.7 miles) lines, non-stop railcars being timed in 1 h. 58 m., and steam stopping rapides in 2 h. 27 m. or 2 h. 36 m.

In Belgium they were first introduced on the Brussels-Antwerp line, which was an easy matter as only electric trains with standard timings were run, and afterwards on the Brussels-Charleroi line, which was much more difficult. From May 1937, they were extended to the Brussels-Liége and Brussels-Ostend lines and in October 1937, to the Brussels-Mons and Brussels-Namur lines, trains leaving Brussels at they round hour, and every 10 or 20 minutes on the Brussels-Antwerp line.

Several countries have developed internal fast services. Belgium has its « block » trains, whose timetables have been standardised, and have been extended to part of the country's fast lines.

Three methods of traction are called upon for the Italian « rapidi ». We have shown them in figure 432. But whilst the electric « rapidi » have been accelerated, the railcars and steam « rapidi » have been decelerated. The only recent changes concern the extension of the Rome-Pisa « rapidi » as far as Genova, the introduction of the Salerno-Taranto service, and the completion of the Sicilian services.

In Switzerland, there are so far but a couple of these limited expresses, running between Geneva and Zurich. In Rumania there is a series of them, but no

TABLE. 349.

EUROPEAN PASSENGER TRAIN FERRY SERVICES.

COUNTRY and connection made.	Crosses the	Between	Railway.	Distance. Km.	Distance. Miles.	Time spent.	Speed. Km./h.	Speed. M.p.h.
ITALY.	**Mediterranean.**							
Italy to Sicily	Messina Strait.	Messina and Villa San Giovanni.	Italian State.	8.0	5.0	0.35	13.7	8.5
Do.	Do.	Messina and Reggio di Calabria.	Do.	15.0	9.3	1.00	15.0	9.3
	Baltic.							
Germany to the Rügen Island	Strelasund.	Stralsund and Altefähr.	Reichsbahn.	2.7	1.7	0.21	7.8	4.8
Rügen Island to Sweden	Baltic.	Sassnitz and Trälleborg.	Reichsbahn and Swedish State.	107.0	66 5	4.10	25.7	16.0
DENMARK.								
Seeland Island to Sweden	Öresund.	Copenhagen and Malmö.	Danish and Swedish State.	29.7	18.4	1.30	20.0	12.4
Do.	Do.	Helsingör and Hälsingborg.	Danish State.	5.1	3.1	0.20	15.0	9.3
Seeland to Falster. . .	Masnedsund.	Masnedö and Orehoved.	Do.	3.5	2.2	0.18	11.7	7.3
Falster to Germany . .	Baltic.	Gedser and Warnemünde.	Do.	44.5	27.6	2.00	22.5	14.0
Falster to Fyn Island .	Great Belt.	Korsör and Nyborg.	Do.	26.0	16.1	1.10	22.3	13.8
Fyn to Jutland. . . .	Little Belt.	Strib and Fredericia (3).	Do.	2.8	1.7	0.15	12.0	7.5
Fyn to Als Island . .	Do.	Faaborg and Mommark.	Mommark Ferry Co.	24.0	14 9	1.20	16.0	9 9
Fyn to Langeland Island	Do.	Svendborg and Rudköbing.	South Fyn Co.	18.0	11.2	1.35 (1)	...	...
In Northern Jutland. .	Limfjorden.	Nyköbing and Glyngöre.	Danish State.	3.7	2.3	0.17 (1)	...	...
Do.	Dô.	South Öddesund and North Öddesund.	Do.	2.5	1.6	0.20 (1)	...	...
Do.	A southern bay of the Limfjorden.	Hvalpsund and Sundsöre.	Do.	1.5	0.9	0.15	6.0	3.7
Fyn to Jutland	South of Little Belt.	Assens and Aarösund (metre gauge).	Little Belt Crossing Co. Ltd.	14.0	8.7	0.50	16.8	10.4
VARIOUS COUNTRIES.	**North Sea.**							
England to France . .	Dover Strait.	Dunkirk and Dover.	Southern Ry.	72.2	44.9	3.55	14.4	9.0
Do.	Do.	Dunkirk and Folkestone.	A.L.A.	85.2	52.9	...	...	...
England to Belgium . .	North Sea.	Harwich and Zeebrugge (2).	L. & N.E. Ry.	159.0	98.8	7.00	22.7	14.1
In Holland	Zuiderzee.	*Stavoren and Enkhuizen* (2) (3).	Netherlands.	24.0	14 9	*1.45*	*13.7*	8.5

(1) The time given includes embarkation.

(2) Transport of goods wagons, quoted for information only.

changes of any importance have taken place. In Denmark, such services are given over to the « lyntog » railcars.

LX-2. — **Ferryboats.** — Table 349 sums up the most interesting data about the 20 European services, 14 of which serve the Baltic coasts and islands (see fig. 287): two others cross the Straits of Messina, and 4, the North Sea. Since writing our earlier articles, no noteworthy changes have been made in the Baltic services, with the single exception due to the completion, on 27th September 1937, of the Storström bridge [1], and there have been no changes in the North Sea and Zuiderzee services.

(a) The DUTCH SERVICES. — Since 1898, the *Netherlands Railways* had run between Stavoren and Enkhuizen, a steam boat service for pasengers and parcels, and a goods train ferry.

The two ferries of 591 gross tons, known as the « Enkhuizen » and the « Stavoren » (figs. 438 and 439) each carried 13 wagons or 350 tons and took 105 minutes to cross, whereas the passenger boats took 68 minutes only. In 1932, the train ferries carried 3 156 wagons on the outward and 2 502 on the return trip. Since the Zuiderzee was closed in by a 30 km. (18.6 miles) long dyke (fig. 440), the difference in level, even in bad weather, is not more than 1 m. (3' 3 3/8").

When the *Netherlands Rys.* took over the operation of the privately-owned railways, there was no longer any reason to use this complicated rail, water and rail route and traffic was thenceforward by rail, around instead of across the Zuiderzee. The number of wagons ferried fell off very rapidly and in April 1936 the service was finally discontinued.

(b) THE DUNKIRK-DOVER service for passenger coaches and goods wagons was worked for the first time on the night of the 14/15 October 1936. The laying out of the landing stages was difficult owing to the great variation in the water level, which reached as much as 5.50 m.

(1) This bridge, 10 535 ft. or just over 2 miles long, is but 8 feet longer than the Tay bridge.

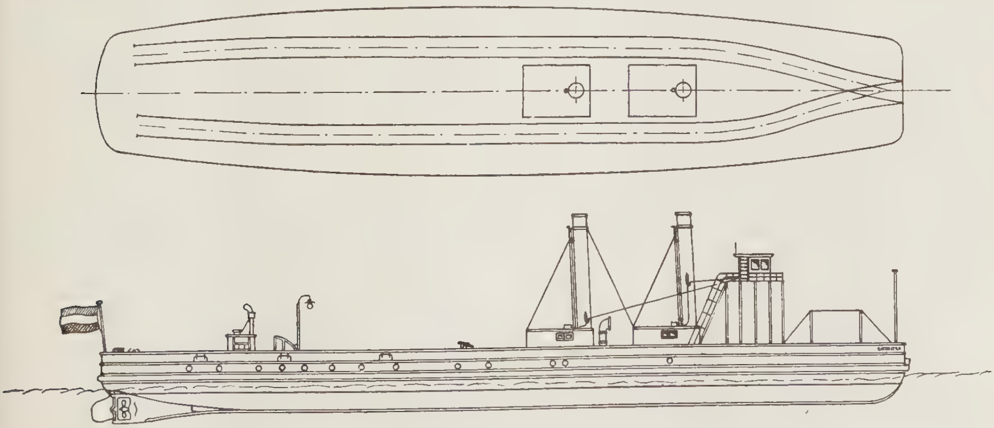


Fig. 438. — *Netherlands Railways'* ferryboat, the « Enkhuizen ».

Fig. 439. — The train ferry « Leeuwarden », of the *Netherlands Railways.*

(18 ft.) at Dunkirk (1). The *Southern Ry.*'s three boats (one of which has been transferred to the French *A.L.A.),* the « Twickenham Ferry », the « Hampton Ferry » and the « Shepperton Ferry », have the following main characteristics :

Length	110 m. (361').
Width	18 m. (59').
Draught	4.20 m. (13' 9").
Tonnage	About 3 000 tons.
Usual speed	15 knots an hour.
Maximum speed. . . .	16 knots on hour.

They have two tracks which by means of 110-m. (5 1/2 chains) radius curves become 4, and have accommodation for 12 sleeping-cars or 30 to 40 wagons (2). On account of the restricted dimensions of the English loading gauge, special sleeping cars were designed, the first of which were shown in figure 133 (3).

(1) It is 6.50 m. (21.3 ft.) at Calais, 8.50 m. (28 ft.) at Boulogne, and reaches 50 ft. (15.50 m.) in the Severn estuary.

The depth of water in Dunkirk harbour is 5 m. (16 1/2 ft.), the level of the track is 7.70 m. (25.2 ft.) on the shore.

(2) Each of the French main-line railways concerned has contributed to the provision of a special stock of wagons of smaller dimensions than their standard ones, suitable for running over the English lines. The *Nord* has supplied 300, the *P.L.M.*, 400; and the P.O.-Midi, 640 : Their leading dimensions are :

Length	7.70 to 10 m. (25' 3" to 32' 9").
Overall width	2.20 m. (7' 3").
Height	2.40 m. (7' 10 1/2").
Surface	17 to 22 m² (183 to 237 sq. ft.).
Capacity	40 to 50 m³ (1 412 to 1 766 cu. ft.).
Useful load, express goods	12 to 15 tons.
Useful load, slow goods	15 to 20 tons.
Tare	12 tons.

We reproduce this information from an excellent article by Mr. LATRASSE, in the *Revue Générale des Chemins de fer*, 2nd half year 1936, p. 232.

(3) See *Bulletin of the Railway Congress*, February 1935, p. 195/335.

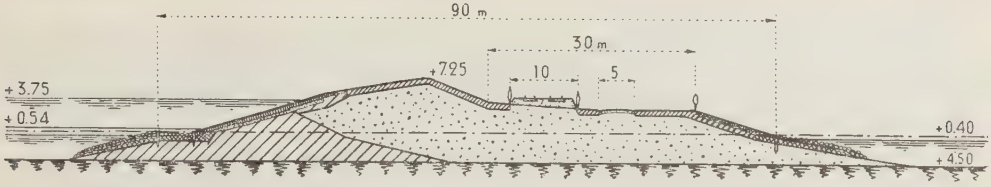


Fig. 440. — Cross section of the Zuiderzee dyke.

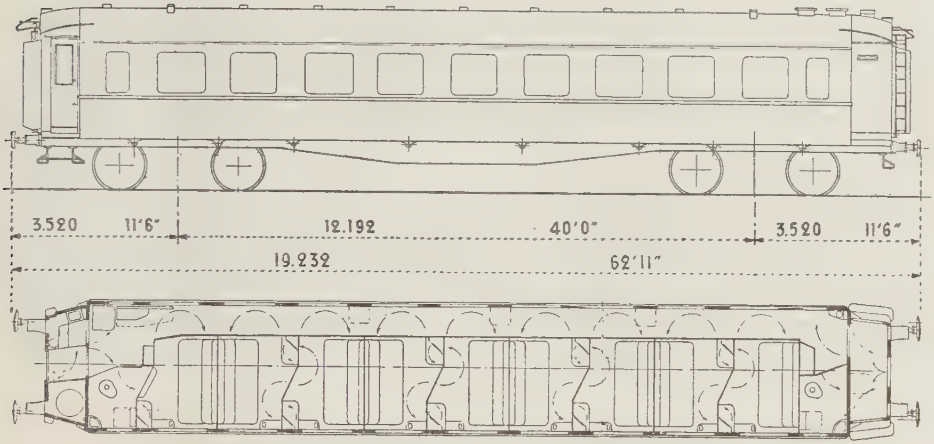


Fig. 441. — Smaller loading gauge sleeping cars built for the *International Sleeping-Car Company's* English services.

The 12 vehicles actually built (fig. 441) contain 18 berths and have the following dimensions, which are interesting to compare with those of the wagons used on the Continent :

Length, between buffers	18 m. (59' 5/8").
Length, overall . .	19.20 m. (63').
Distance between bogie centres . . .	12.20 m. (40').
Height above rail level	3.90 m. (12' 9 9/16").
Overall width . . .	3.75 m. (12' 3 1/2").

Figure 442 gives their cross section.

(c) THE HARWICH-ZEEBRUGGE SERVICE only carries goods wagons. It is worked by means of three large 4-track train ferries (figs. 444 to 446), 1 112 feet (356 m.) long, which can carry 54 ten-ton wagons, or 850 Engl. tons (862 t.).

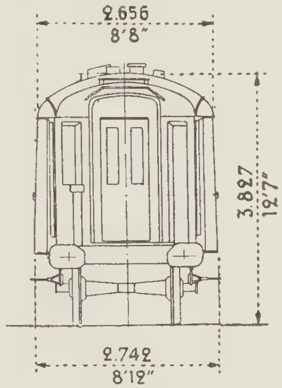


Fig. 442. — End view of sleeping-cars built by the *International Sleeping-Car Company* to suit the English gauge.

Their leading dimensions are :

Total length. . . .	363 1/2 f. (110.79 m.).
Total width	61 1/2 f. (18.74 m.).
Draught	9 1/2 f. (2.89 m.).
Displacement . . .	3 654 tons.
Speed	12 knots.

Fig. 443. — *Southern Fyn Company*'s ferryboat.

The crossing usually takes 7 to 7 1/2 hours. Owing to its geographical situation, this service can be worked more regularly than the south-westerly services, which is a very great advantage for the consignors.

(d) THE SERVICES ACROSS THE STRAITS OF MESSINA have not been modified mate-

TABLE 350.

LEADING DIMENSIONS OF THE ITALIAN TRAIN FERRIES.

Boat.	Length, metres *(feet).*	Width, metres *(ft. in.).*	Depth, metres *(ft. in.).*	Draught, metres *(ft. in.).*	Displacement, metric *(Engl.* tons).	Speed. km. *(miles)* p. h.	Number of tracks.	Useful track length, metres *(feet).*
Cariddi . .	109.10 (358')	17.20 (56' 5")	6.25 (20' 6")	3.80 (12' 6")	4 034 (3 970)	15.5 (9.6)	3	254 (833')
Scilla . .	109.10 (358')	17.20 (56' 5")	6.25 (20' 6")	3.80 (12' 6")	4 034 (3 970)	15.5 (9.6)	3	254 (833')
Messina . .	93.90 (308')	11.85 (38'10 1/2")	4.65 (15' 3")	3.25 (10' 8")	2 208.9 (2 174)	12 (7.5)	3	206 (676')
Aspromonte.	82.80 (272')	10.30 (33' 9 1/2")	4.27 14' 0")	2.80 (9' 2 1/4")	1 262 (1 242)	15.5 (9.6)	1	78 (256')
Reggio . .	82.80 (272')	10.30 (33' 9 1/2")	4.27 14' 0")	2.80 (9' 2 1/4")	1 262 (1 242)	14 (8.7)	1	78 (256')
Villa . . .	82.80 (272')	10.30 (33' 9 1/2")	4.27 14' 0")	2.80 (9' 2 1/4")	1 262 (1 242)	13 (8.1)	1	78 (256')

Fig. 444. — Train ferry of the Harwich-Zeebrugge line.

Fig. 445. — Arrangement of the tracks for embarking on a Harwich-Zeebrugge train ferry.

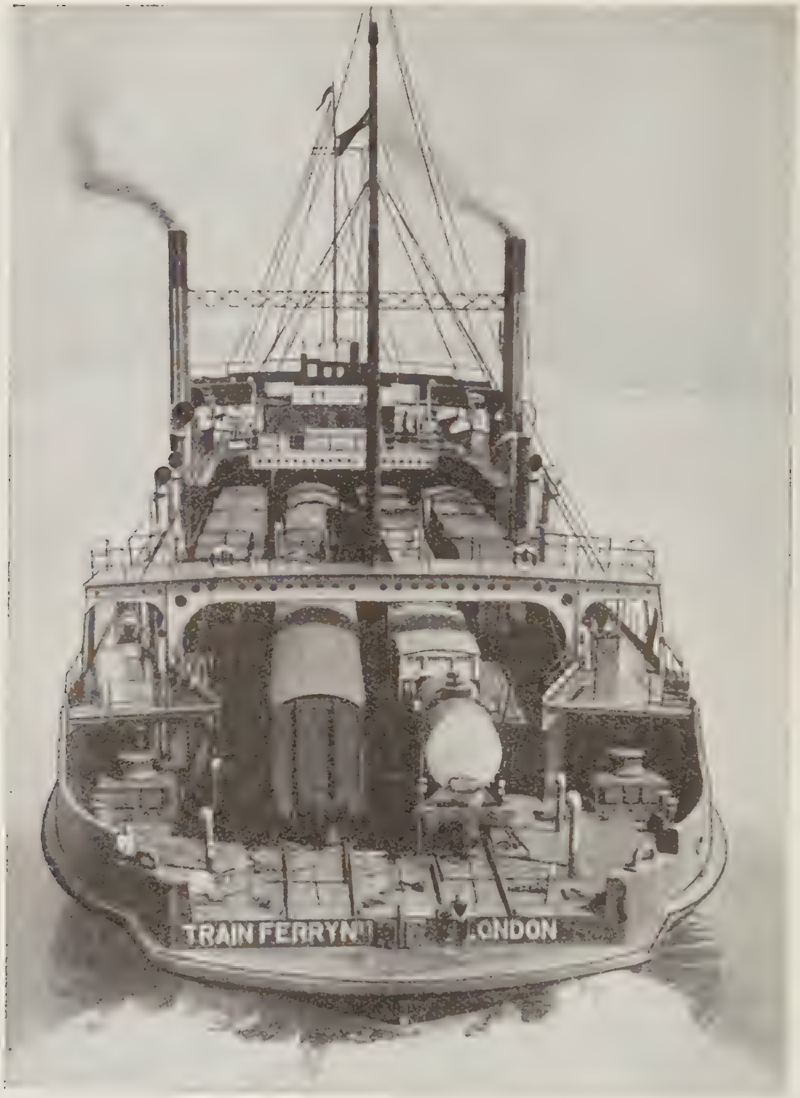


Fig. 446. — Harwich-Zeebrugge 4-track train ferry.

rially; but slight changes are made to suit the traffic fluctuations. There are now seven crossings daily from Messina to Villa San Giovanni, and 4 from Messina to Reggio di Calabria. During the 5 months of heavy traffic, there may be as many as 5 additional crossings daily between Messina and each of the other two ports.

The boats are particularly comfortable for passengers (figs. 447 and 448). The recent units are among the best in existence.

The « Cariddi » and the « Scilla » have

Fig. 447. — Lounge of the Italian ferryboat « Scilla ».

diesel-electric power plant, the « Messina » and the « Aspromonte » diesel engines, and the « Villa San Giovanni » and « Reggio » are steamers.

The single-track ferries are used on the Reggio di Calabria service, and the others on the Villa San Giovanni.

LX-3. — **The International Sleeping Car Company's services.** — During the last few years these services have undergone three kinds of alterations :

(a) Many « de luxe » trains no longer run as independent units; they now consist of sleeping cars, and if need be a restaurant car, attached to ordinary expresses.

(b) In order to reduce train-mileage, the route of certain trains was altered, especially of those that where split up into two rakes. In several instances the whole train now follows the shortest route, and then continues to the terminus of the longer itinerary. This is the exact opposite of what is done in times of prosperity.

Formerly, for example, coaches for Biarritz were detached from the « Sud-Express » and the « Pyrénées-Côte d'Argent Express » at La Négresse. Both these trains now run to Biarritz, then return, and run on to Hendaye.

Similarly the « Rome Express » was split up at Pisa, whence one rake ran to Florence [either by the direct route,

Fig. 448. — Promenade deck of the ferryboat « Scilla ».

or by the Montecatini route, which was only 1 km. (0.6 mile) longer, but along a worse line], while the main part of the train proceeded via Leghorn to Rome (fig. 432). Since the economic sanctions, the whole train runs to Florence and thence to Rome, thus increasing the run by 67 km. (41.6 miles). The *Int. Sleeping-Car Co.*'s timetables still give this route whereas the contemporaneous *Italian Ry.*'s restored the « Rome Express » to the pre-sanction Leghorn-Rome line.

Mention should also be made of two extensions and two new trains.

The « Oiseau Bleu » has been extended from Antwerp to Amsterdam, and duplicates the « Etoile du Nord » from Paris. The Brussels-Amsterdam line is, therefore the only European one to be served daily by three Pullman trains in each direction, as the « Edelweiss », from Switzerland, also uses it. On the other hand, in 1936, the « Nord Express » was extended from Warsaw as far as the Russian frontier, towards Moscow, and thus again follows its pre-war route here.

As to new trains, the « Tyrol Express », on days when the « Arlberg-Orient Express » does not run, is an extension, between Sargans and Salzburg of the Company's train from Paris and Calais. Beyond Salzburg, it picks up the route of the « Orient Express ». As in the case of the « Arlberg-Orient Express », the rakes known as the « Oberland Express »

and « Engadine Express » are attached to this train in France.

A more important train is the Paris-London (Victoria) all-sleeping-car train which is ferried across between Dunkirk and Dover and also carries day coaches. It takes 11 h. 10 m. on the outward journey and exactly 11 hours for the return. The connecting express trains from Paris to Dunkirk-Station and back take respectively 3 h. 22 m. and 3 h. 26 m., i.e. an average speed of 90.6 and 88.8 km. (56.3 and 55.2 miles) an hour. Provision is made for long stops both at Dover and Dunkirk.

This is the second of the *International Sleeping-Car Co.*'s English services. In 1889-1890 there also were London-Paris services, but they ran by day. The Company's « club-trains » ran both between London (Charing Cross) and Dover, over the former *South Eastern Ry.*'s metals, as well as between London (Victoria) and Dover, over the *London, Chatham & Dover Ry.*'s

(c) Mention must finally be made of the many Pullman-cars that have been withdrawn or converted into restaurant-car services.

To complete the information previously given, figure 449 shows one of the old six-wheeled sleeping-cars built by the *La Croyère* Works (1).

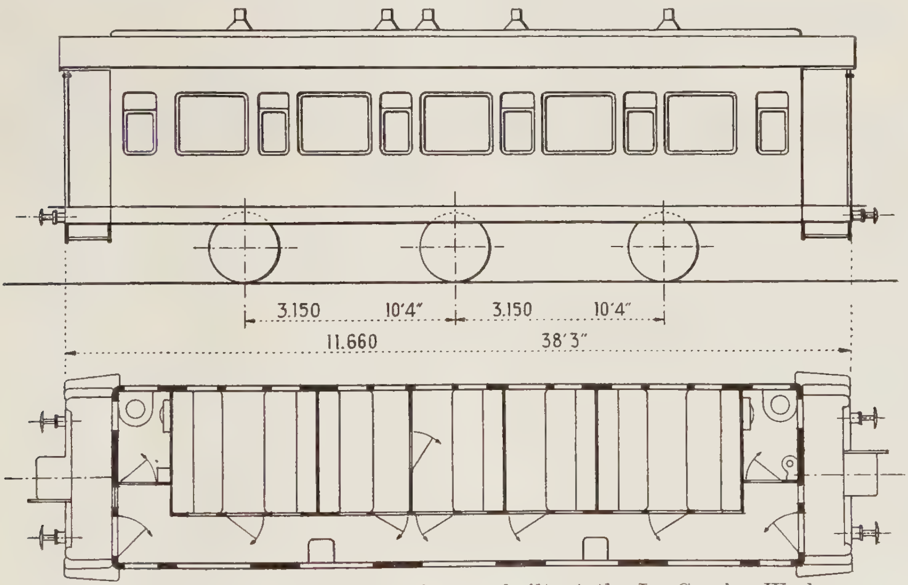


Fig. 449. — Old six-wheeled sleeping-car built at the La Croyère Works, about 1875. for the *Int. Sleeping-Car Co.*

(1) The leading dimensions were :

Body length.	10.250 m. (33' 7 35/64").
Overall length	11.050 m. (36' 3").
Outside width	2.800 m. (9' 2 15/64").
Height above rail level	3.750 m. (12' 3 5/8").
Diameter of wheels	1.050 m. (3' 5 11/32").
Total wheelbase	6.300 m. (20' 8").

The two-berth compartments were 1.870 m. by 1.350 m. (6' 1 5/8" × 4' 5 1/4").

CHAPTER LXI.

Appendix. — Supplementary information.

So as to complete the data previously given, we here append some further information solely for reference purposes.

1. **Track gauges.** — Besides Ireland and the Iberian Peninsula, which have retained the broad gauge, this gauge was formerly used in several countries that have since discarded it; the 1.60-m. (5' 3") in Baden, and the north of Switzerland (1), and the 1.94-m. (6' 4 3/8") gauge in Holland (2).

In Great Britain, there was at the inception, still greater diversity of gauges. The 5-foot (1.524-m.) track was used by the former *Eastern Counties Ry.* as far as Chelmsford and Cambridge (3) (lines now owned by the *L.N.E. Ry.*) and gauges of from 4' 6" to 5' 6" (1.37 to 1.68 m.), in Scotland.

The greatest mileage of broad-gauge lines was laid by Brunel, the *Great Western*'s brillant chief engineer. This gauge was 7' 1/4" (2.14 m.) (fig. 450), which

TABLE 351.

SECTIONS OF THE GREAT WESTERN RAILWAY ORIGINALLY LAID TO 7' 1/4" (2.14-M.) GAUGE.

SECTION.	Length		Date converted to standard gauge.
	Km.	Miles.	
Princes Rixborough-Aylesbury	11	6.8	1868
Oxford-Wolverhampton	144	89.5	1869
Grange Court (near Gloucester)-Hereford	35	21.7	1869
Reading-Basingstoke	26	16.2	1869
Maidenhead-Oxford	60	37.3	1870
West Drayton-Uxbridge	4	2.5	1871
Whitland-Carmarthen	22	13.7	1871
Swindon-Milford and branches	384	238.6	1872
Vale of Neath, Merthyr and Cheltenham to Grange Court branches	96	59.7	1872
Radley-Abingdon	3	1.9	1872
Didcot-Oxford	17	10.6	1872
Bristol & South Wales Union Railway	19	11.9	1873
Thingley Junction-Dorchester : Westbury-Salisbury, Bathampton-Bradford Junction, Bristol-Frome, Reading-Holt Junction and branches	317	197.0	1874
Dorchester-Weymouth-Southcote Jn.-Reading	14	8.7	1874
Branches	24	14.9	1875-1880
Durston-Yeovil	33	20.5	1880
Barnstaple-Norton-Fitzwarren-Minehead	108	67.1	1881-1882
Tiverton Junction-Tiverton	7	4.4	1884
Creech Junction-Chard	19	11.9	1891
London-Penzance	482	299.5	1892
Mutley-Lauceston	...	...	...

(1) See *Bulletin*, August 1937, pp. 1711/1712.
(2) See *Bulletin*, March 1935, p. 280/368.
(3) It was converted to standard gauge in 1844.

Fig. 450. — *Great Western Ry.*'s broad gauge (2.14-m. = 7' 1/4") lines, converted to standard gauge on the dates given in table 351.

made it possible to run from the start at speeds which were quite remarkable for the time. As early as 1846, only 57 minutes were allowed for the 53 miles (85 km.) between London and Didcot; yet this included the stop at Didcot so that in practice the run was often made in 50 minutes and even in 47 1/2 minutes (1).

The broad gauge mileage eventually aggregated a length of 2 214 km. (1 376 miles).

Although the *Gauge Regulation Act of 1846* did not apply to the *Great Western Ry.* or its subsidiaries, in the end the Company felt compelled to convert its system to the standard gauge. A beginning was made in 1868 when the Princes Rixborough and Aylesbury 11 km. (6.8 miles) were thus altered but for some time already certain sections, often of considerable length, had been equipped with a third rail. The last broad gauge section was converted in 1892 (2).

The London *Metropolitan Ry.* being an extension of the *Great Western* as far as Farringdon Street, was originally laid to 2 m. 14 (7' 1/4") gauge and opened to traffic in 1863; it was soon equipped with a third rail to make it suitable for both gauges. The outer line of rails was removed in 1869, thus retaining standard gauge track only.

SCOTLAND. — In Scotland there was even greater diversity of gauges than in England. The *London Midland & Scottish Ry.* has kindly supplied us with the following hitherto unpublished information on the subject, for which we are very grateful (3).

Both the *Wishaw and Colness Ry.*, and

(1) See ACWORTH : « The Railways of England ».
(2) Further details will be found in an earlier article published in the *Bulletin*, February 1923, pp. 182/100 et seq.
(3) All these railways except the Dundee-Arbroath line which it jointly owns with the *L.N.E.Ry.*, now form part of the *London Midland & Scottish Ry.*

the *Glasgow Garnkirk & Coatbridge Ry.* were built to 4' 6" (1.371 m.) gauge, and converted to standard gauge in 1844 and 1845 respectively so as to comply with the Gauge Regulation Act.

The *Kilmarnock and Troon Ry.*, built to 4-foot (1.219 m.) gauge, and its branch line from Drybridge to Fairlie, of 3' 4" (1.016-m.) gauge, were converted to standard gauge in 1846.

The 5' 6" (1.676-m.) gauge of the *Arbroath and Forfar Ry.* and the *Dundee and Arbroath Ry.* was converted to 4' 8 1/2" (1.435 m.) in 1846; the next year the *Dundee and Newtyle Ry.*, the *Newtyle and Glamis Ry.* and the *Newtyle and Coupar Angus Ry.* were dealt with in the same way.

IRELAND. — The *Ulster Ry.*, built in 1836 to the 6-foot (1.82-m.) gauge was converted to the standard gauge of the country (5' 3" = 1.60 m.) when this railway was amalgamated with the other lines forming the *Great Northern Ry.* [1].

SWEDEN AND FINLAND. — When war was declared in 1914, the standard-gauge lines of the Swedish system ended at Karungi, while the Finnish lines built to the Russian gauge of 1.52 m. (5') ran as far as the frontier river at Haparanda. The Swedes extended their railway from Karungi to the Tornea frontier river and the bridge which was opened to traffic in 1919 carried a 4-rail track.

2. **Loading gauges.** — To complete the information given on this subject, figures 451 to 453 show the loading gauges of the Irish 5' 3" and 3' (1.60 and 0.91-m.) lines, and figure 454 the loading gauge of the 1.52 m. (5') track on the *Finnish* Railways, which is practically the same as that of the U. S. S. R.

3. **Bridges.** — *(a)* We have previously quoted the most important Danubian railway bridges, above Rumania. The length of the RUMANIAN RAILWAY BRIDGES are as follows :

Borcea.	970 m. (3 182').
Ezer.	1 455 m. (4 774').
Regele Carol I	1 663 m. (5 489').

(b) LONGEST BRITISH RAILWAY BRIDGES :

Firth of Forth	2 529 m. (8 298')	Former North British Ry.
Tay Bridge	3 286 m. (10 780').	Do.
Solway Firth	1 804 m. (5 820').	Demolished in 1934.
Saltash Bridge	678 m. (2 190').	Great Western Ry.
Royal Border (Berwick on Tweed) .	669.6 m. (2 160').	
Britannia Tubular bridge	468 m. (1 510').	Over the Menai Straits.

4. **Tunnels** : (1) GREAT BRITAIN. — Two important tunnels have been driven under the Severn and Mersey estuaries. Apart from these, there are in England alone, 31 tunnels over 2 km. (1.24 miles) long. These are given in table 353.

The longest continuous tunnel in the London underground system is 16 miles 1 100 yards (26 775 m.) long, from Golder's Green to Morden, via the Bank.

(2) The ITALIAN STATE RYS., one of the Systems having most tunnels, have kind-

(1) Apart from this exceptional gauge, the Irish system is built to the 5' 3" gauge, and certain 3' gauge lines have been converted to the 5' 3").

The opposite took place more frequently. Thus the *Finn Valley Ry.* (from Strabane to Stranorlar) was reduced to 3' gauge in 1892 when amalgamated with the *West Donegal* to make up the *County Donegal Ry.* The same thing happened to the Cork-Passage section of the *Cork Blackrock and Passage Ry.* (1903).

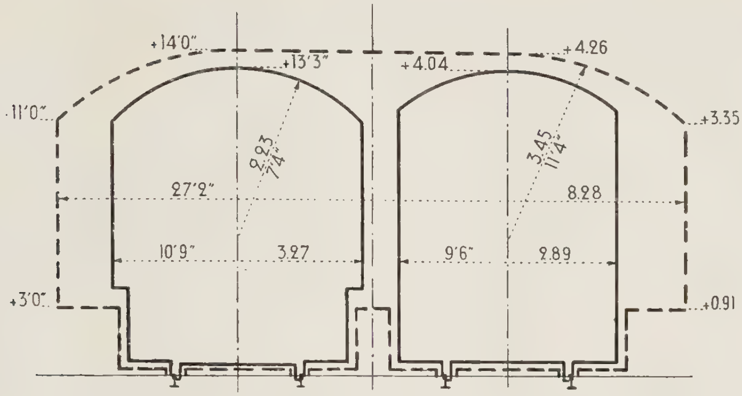
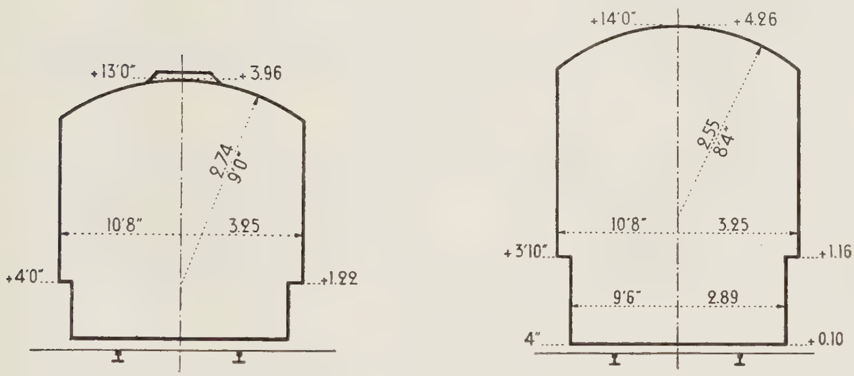


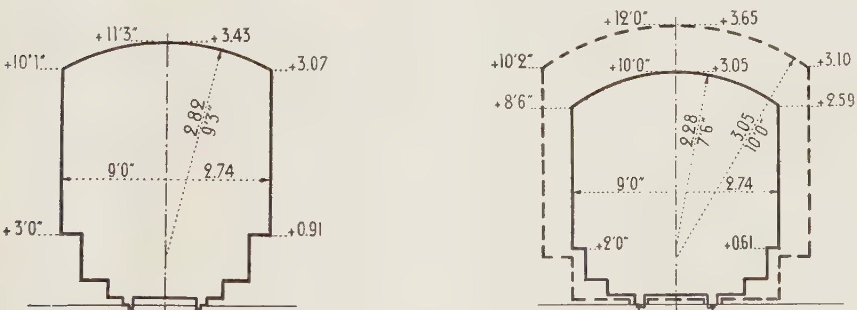
Fig. 451. — 160-m. (5' 3") track loading gauge, *Great Northern of Ireland Ry.*



(a) Former Queenstown, Kildare, Limerick, etc. system.

(b) Former N. Wall-Galway, Enfield-Edenderry, etc. system.

Fig. 452. — 160-m. (5' 3") track loading gauges, *Great Northern of Ireland Ry.*



(a) Great Northern of Ireland.

(b) Northern Counties Committee.

Fig. 453. — 0.91-m. (3') track loading gauges.

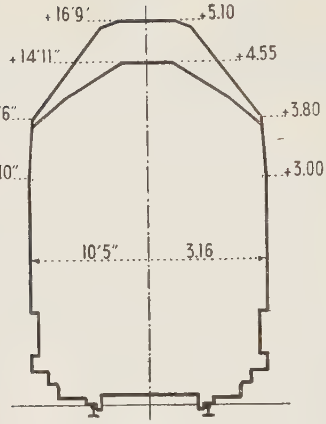


Fig. 454. — *Finnish Rys.'* 1.52-m. (4' 11 3/4") track loading gauge.
The inner line shows the loading gauge on certain lines of the system.

ly furnished us with a list of those over 2 km. (1.24 miles) in length. In spite or, perhaps, we should say, because of their number, it is interesting to quote them here for reference purposes. We would draw attention to the numerous tunnels on the coastal lines from Genova to La Spezia and from Battipaglia to Reggio C. These tunnels continue even beyond the Straits as the line from Messina crosses Mount Pelirotany at the top of a very steep gradient, through a 5.445-km. (3.38 miles) tunnel, so as to reach the northern coast of the island.

These tables (No. 354) are here published for the first time.

(9) SWITZERLAND. — A slip occurred in Table 201, in the July 1935 issue of the

TABLE 352.
LENGTH OF RAILWAY BRIDGES OVER THE LARGER DUTCH RIVERS.

Place.	River.	Length	
		Metres.	Feet.
	Arms of the Rhine and Meuse.		
Nymegen.	The Waal.	687	2 254
Bommel.	Do.	870	2 854
Baanhoek.	The Merwede.	477	1 565
Dordrecht.	The Old Meuse.	402	1 319
Oosterbeek.	The Rhine.	478	1 568
Rhenen.	Do.	532	1 745
Culembourg.	The Lek.	670	2 198
Rotterdam.	The King's Harbour.	216	709
...	The New Meuse.	402	1 319
Westervoort.	The IJssel.	470	1 542
Zutphen.	Do.	361	1 184
Deventer.	Do.	521	1 709
Zwolle. (Hattemeerbroeck)	Do.	434	1 424
Maastricht.	The Meuse.	198	650
Roermond. (Buggenum)	Do.	263	863
Venlo.	Do.	231	758
Gennep.	Do.	317	1 040
Heumen (Mook) .	Do.	355	1 165
Ravenstein.	Do.	341	1 119
Hedel. (Crèvecœur).	Do.	718	2 356
Moerdijk.	The Hollandsch Diep.	1 469	4 820

TABLE 353.

ENGLISH TUNNELS OVER 2 KM. (1.24 MILES) LONG.

Former System.	TUNNEL.	Length: Metres	Length: Miles and yards.
Great Western Ry.			
...	Severn Tunnel.	7 035	4 m.- 654
...	Sodbury.	4 054	2 m.- 913
...	Rhondda.	3 148	1 m.-1 683
...	Box Tunnel.	2 940	1 m.-1 452
...	Merthyr.	2 281	1 m.- 735
Mersey Railway.			
...	Mersey Tunnel.	1 929	1 m.- 350
London Midland and Scottish Ry.			
Midland.	Botley.	5 696	3 m.- 950
Do.	Disley.	3 535	2 m.- 346
Do.	Cowburn.	3 385	2 m.- 182
Do.	Dove Holes.	2 729	1 m.-1 224
Do.	Bleamoor.	2 759	1 m.- 629
L. and N. Western.	Stanledge.	4 883	3 m.- 60
Do.	Festiniog.	3 407	2 m.- 206
Do.	Morley.	3 063	1 m.-1 590
Do.	Victoria (Liv.).	2 523	1 m.-1 000
Do.	Kilsby.	2 218	1 m.- 666
Do.	Gildersome.	2 131	1 m.- 571
Lanc. and Yorksh.	Littleborough.	2 638	1 m.-1 125
London and N. Eastern Ry.			
Gt. Central.	Woodhead.	4 840	3 m.- 13
Do.	Catesby.	2 740	1 m.-1 237
Do.	Bolsover.	2 399	1 m.- 864
Gr. Northern.	Ponsbourne.	2 454	1 m.- 924
Do.	Queensbury.	2 287	1 m.- 741
N. Eastern.	Bramhope.	3 433	2 m.- 234
Southern Ry.			
L.B. and S.C. Ry.	Oxted.	2 121	1 m.- 506
Do.	Clayton.	2 121	1 m.- 506
S.E. and Chatham Ry.	Sevenoaks.	3 155	1 m.-1 691
Do.	Polhill.	2 368	1 m.- 829
Do.	Shepherd's Well.	2 154	1 m.- 605
Do.	Strood.	2 124	1 m.- 563
Do.	Sydenham.	2 011	1 m.- 440

TABLE 354
ITALIAN TUNNELS OVER 2 KM. (1.24 MILES) IN LENGTH.

Line.	Tunnel. Name.	Length Metres.	Length Miles.	Maximum altitude Metres.	Maximum altitude Feet.
Alessandria-Arona	Valenza.	2 330.06	1.45	122.03	400.3
Asti-Chivasso.	Brozolo.	2 348.21	1.46	261.92	859.3
Cuneo-Vievola	Colle di Tenda.	8 098.64	5.03	1 040.45	3 413.5
Santhià-Borgomanero-Arona	Gattico.	3 308.63	2.06	298.10	978.0
Savona-Brà	Colle Sella.	2 309.00	1.43	329.80	1 082.0
Do.	Colle Belbo.	4 246.90	2.64	515.15	1 690.1
Torino-Modane	Del Frejus.	13 635.75	8.47	1 295.00	4 248.6
Fossano-Mondovì-Ceva . .	S. Giovanni.	2 803.60	1.74	454.87	1 492.3
Domodossola-Iselle. . . .	Elicoidale di Varzo.	2 967.99	1.84	568.20	1 863.6
Oleggio-Pino	Varallo Pombia.	2 687.24	1.67	222.90	731.3
Do.	Laveno.	2 934.90	1.82	208.50	684.0
Genova-La Spezia. . . .	Ruta.	3 086.00	1 92	37.48	123.0
Do.	Delle Grazie.	2 164.62	1.35	12.46	40.9
Do.	Vallegrande.	4 007.10	2.49	26.64	87.4
Do.	del Rospo.	2 532.55	1.57	17.27	56 7
Do.	Picchi.	2 335.91	1.45	15.19	49.8
Do.	Mesco.	3 034.56	1.88	16.28	53.4
Do.	Monterosso Ruvano.	2 886.87	1.79	17.27	56.7
Do.	Biassa.	5 145.93	3.19	28 85	94.65
Ronco-Arquata	Borlasca.	4 048.80	2.51	293.59	96.3
Torino-Genova	Dei Giovi.	3 264.76	2.03	311.02	102.0
Succursale dei Giovi . . .	Ronco.	8 297.55	5.15	276.30	906.5
Genova-Ventimiglia . . .	Capo Berta.	2 435 07	1.51	6.184	20.3
Genova-Ovada-Asti. . . .	Turchino.	6 447.64	4.00	316.21	1 037.4
Do.	Cremolino.	3 408.16	2.11	216.46	710.2
Trieste C.M.-Piedicolle . .	Wocheim.	6 338.66	3.97	534.34	1 749.7
DD. BOLOGNA-FLORENCE	Grande galleria del l'Appennino.	18 507.38	1.15	323.02	1 059.7
Do.	Pian di Setta.	3 052.02	1.89	294.90	967.5
Do.	Monte Adone.	7 135.35	4.43	181.65	595.9
Bologna-Pistoia (Porrettana).	Dell'Appennino.	2 727.22	1.69	580.11	1 905.0
Bologna-Pistoia (Porrettana).	Piano Casale.	2 621.54	1.63	296.80	973.7
Florence-Faenza	Pratolino.	3 584.30	2.22	302.09	991.1
Do.	Monzagnano.	2 335.89	1.45	451.47	1 481.2
Do.	Appennino.	3 778.28	2.35	578.38	1 897.6
Parma-La Spezzia	Groppo S. Giovanni.	2 489.49	1.55	305.46	1 002.2

TABLE 354 (*Continued*).

LINE.	TUNNEL.				
	Name.	Length		Maximum altitude	
		Metres.	Miles.	Metres.	Feet.
Parma-La Spezia	Maccagnana.	2 271.92	1.41	373.10	1 224.1
Do.	Borgallo.	7 971.54	4 95	431.32	1 415.1
Roma-Avezzano	Monte Bove.	3 938.85	2.44	801.00	2 627.9
DD. ROME-NAPLES. . .	Mont'Orso.	7 530.51	4.68	53.60	175.8
Do. . . .	Vivola.	7 454.53	4.63	94 80	311.0
Do. . . .	Monte Massico.	5 378.00	3 34	46.24	151.7
Do. . . .	Metropolitana.	5 283.00	3.28	13.00	32.8
Sulmonia-Isernia	Monte Pagano.	3 109.72	1.93	945.04	3 101.7
Do.	Monte Totila.	2 175.15	1.35	771.05	2 529.5
Do.	Maiella.	2 485.08	1.54	1 258.36	4 062.8
Roccasecca-Avezzano . . .	Scrime.	2 152.49	1.37	271.08	889.4
Rome-Sulmona	Carrito.	3 544 69	2.20	907.63	2 977.7
Foggia-Naples	Ariano.	3 205.00	1.99	523.46	1 717.4
Do.	della Starsa.	2 600.00	1.61	383.00	1 256.5
Salerno-Mercato San Severino	Elicoidale di Fratte.	2 395.00	1.49	74.48	244.4
Cancello-Avellino	Turci.	2 425.00	1.50	393.50	1 291.0
Avellino-Rocchetta	Montefalcione.	2 595.00	1.61	444.15	1 457.2
Palermo C.-Messina . . .	Carbone.	2 055.00	1.27	22.40	73.5
Do. . . .	Tindari.	2 122.00	1.32	11 85	38.9
Do. . . .	Peloritana.	5 446.00	3.38	155.02	508.5
Fiumetorto-Bicocca. . . .	Magazzinazzo.	2 238.00	1.39	536.75	1 761.0
Do.	Marianopoli.	6 477.00	4.02	354.67	1 163.6
Castelvetrano-P. Empedocle.	S. Giorgio.	3 768.00	2.34	53.59	175.8
Battipaglia-Reggio C. . .	Rutino.	4 408.70	2.74	127.50	418.3
Do. . . .	Spina.	3 282.73	2.04	79.80	261.8
Do. . . .	S. Cataldo.	5 141.93	3.19	82.93	272.0
Do. . . .	Acquafredda.	3 898.50	2.42	52.27	171.5
Do. . . .	Dell'Arma.	2 254.76	1 40	90.00	295.3
Do. . . .	Maratea.	2 390.52	1.48	86.50	283.7
Do. . . .	Castrocucco.	2 547.88	1.58	24.60	80.7
Do. . . .	Coccorino.	2 360.00	1.47	52.50	172 2
Do. . . .	S. Elia-Torre di Palmi.	2 444.93	1.52	72.58	56.6
Do. . . .	Ianculla-Leone-Frana.	2 662.41	1.65	61.12	200 5
Taranto-Reggio C. . . .	Cutro.	2 722.45	1.69	101.43	332.7
Paola-Cosenza	Appennino.	4 167.65	2.59	539.90	1 771.3
S. Eufemia L.-Catanzaro M.	Sansinato.	2 444.79	1.52	122.02	400.3
Foggia-Potenza	Appennino.	3 320.03	2.06	773.32	2 537.1

TABLE 355

AUSTRIAN TELPHER LINES.

Telpher line.	Horizontal length		Actual length		Altitude				Passengers carried		Speed		Time spent, minutes.
					Lower		Upper						
	Km.	Miles.	Km.	Miles.	Metres.	Feet.	Metres.	Feet.	Standing.	Seated.	M./sec.	Ft./sec.	
Feuerkogelbahn (Ebensee) .	2.684	1.66	2.903	1.80	469	1 539	1 579	5 180	11	4	3.6	11.8	14
Hahnenkammbahn (Kitzbühel	2.193	1.36	2.390	1.48	770	2 526	1 641	5 384	15	2	3.5	11.5	12
Innsbrücker Nordkettenbahn	3.369	2.09	3.637	2.26	860	2 821	2 256	7 402	19	4	3.6	11.8	20
Kanzelbahn (Annenheim) .	1.660	1.03	1.910	1.19	526	1 726	1 500	4 920	19	4	3.6	11.8	10
Bürgeralpenbahn (Maria Zell)	1.392	0.86	1.432	0.89	890	2 920	1 254	4 114	16	7	3.5	11.5	10
Obervellach Markt-Bahnhof.	0.941	0.58	1.007	0.62	701	2 300	1 060	3 478	12	4	3.5	11.5	6
Bürgeralpenbahn	...	...	1.432	0.89	...	...	...	...	...	...	3.5	11.5	...
Patscherkofelbahn (Innsbrück)	3.531	2.19	3.788	2.35	891	2 923	1 945	...	19	4	3.6	11.8	20
Nordkettenbahn.	...	...	2.885+0.752	1.79+0.47	...	...	...	...	...	...	4.0	13.1	...
Pfänderbahn (Onegenz) . .	1.980	1.23	2.073	1.27	418	1 371	1 060	3 478	19	4	4.0	13.1	10
Raxbahn (Hirschwang) . .	1.895	1.17	2.151	1.34	527	1 729	1 548	5 079	19	4	4.0	13.1	10
Schmittenhöhenbahn (Zell am See).	2.576	1.60	2.767	1.72	948	3 110	1 968	6 457	19	4	4.0	13.1	13
Österr. Zugspitzbahn (Ehrwald)	3.014	1.87	3 360	2.09	1 225	4 019	2 850	9 203	15	4	3.6	11.8	18

TABLE 356.

THE AUSTRIAN LAKES.

LAKE.	Altitude.		Maximum length		Maximum width		Maximum depth		Area		Speed of boats	
	Metres	Feet.	Km.	Miles.	Km.	Miles.	Metres	Feet.	Km².	Sq. miles.	Km./h.	M.p.h.
Achensee	929	3 048	8.97	5.6	1.02	0.63	184	604	6.75	2.61	10 — 15	6.2 — 9.3
Attersee	465	1 526	19.50	12.1	3.15	1.96	170.6	560	46.72	18.04	10 — 20	6.2 — 12.4
Bodensee	395	1 296	69.00	42.9	13.50	8.39	252	827	539(1)	208(1)	20 — 30	12.4 — 18.6
Grundlsee	709	2 326	5.75	3.57	1.04	0.65	63.8	209	4.14	1.60	10 — 15	6.2 — 9.3
Hallstättersee	494	1 621	5.08	3.16	2.07	1.29	125	410	8.6	3.32	10 — 15	6.2 — 9.3
Kammersee	725	2 379	0.60	0.37	0.45	0.28	7	23	...	...	...	...
Millstättersee	580	1 903	11.00	6.84	1.81	1.12	140.7	462	13.25	5.12	10 — 20	6.2 — 12.4
Mondsee	479	1 572	9.45	5.87	2.90	1.80	68.3	224	14.21	5.49	10 — 15	6.2 — 9.3
Neusiedlersee	116	381	45.00	28.0	18.00	11.18	7	23	335(2)	129.3(2)	...	...
Ossiachersee	490	1 608	8.85	5.50	1.51	9.38	46.5	153	10.6	4.09	10 — 20	6.2 — 12.4
Plansee	976	3 202	5.20	3.23	0.80	0.50	76	249	2.8	1.08	10 — 15	6.2 — 9.3
Toplitzsee	716	2 349	2.00	1.24	0.90	0.56	112	367	4.6	1.78	...	...
Traunsee	422	1 384	11.62	7.21	2.95	1.83	191	627	25.6	9.88	15 — 20	9.3 — 12.4
Weissensee	921	3 022	11.90	7.39	0.90	0.56	97	318	6.6	2.55	...	...
Wolfgangsee	539	1 768	11.12	6.90	1.925	1.19	114	374	13.15	5.08	10 — 15	6.2 — 9.3
Wörthersee	439	1 440	16.60	9.9	2.00	1.24	84.6	277	19.4	7.35	10 — 20	6.2 — 12.4
Zellersee	753	2 470	4.10	2.55	1.50	0.93	69	226	4.7	1.81	...	...
Heiterwangersee	720	2 362	0.80	0.50	0.80	0.50	70	230	0.7	0.25	10	6.2

(1) Including 50 km² (19.3 sq. miles) of Austrian territorial waters.
(2) 290 km² (112 sq. miles) of which in Austria, the remainder in Hungary.

Bulletin, the ownership of the Simplon tunnel being erroneously attributed to the *Bern-Lötschberg-Simplon Ry.* instead of the *Swiss Federal Rys.*, as was correctly stated in the text.

5. **Railway gradients.** — Additional information received from the *Rumanian State Railways.*

(a) CARANSEBES-SUBCETATE LINE.

	Distance		Altitude	
	Km.	Miles.	Metres.	Feet.
Caransebes	0	0	204	669
Boutari	34	21.1	425	1 394
Iron Gates	47	29.2	692	2270
Sarmisegetuza	56	34.8	481	1 578
Subcetate	77	47.8	297	974

Rack sections with 1 in 20 gradients exist from Butari up to the Iron Gates and down again to Sarmisegetuza. Elsewhere, gradients do not exceed 1 in 40; 250 m. (12 1/2 chains) is the minimum radius of curves.

(b) DARMANESTI-VATRA DORNEI-DORNISOARA LINE.

	Distance		Altitude	
	Km.	Miles.	Metres.	Feet.
Darmanesti	0	0	294	965
Cacica	21	13.0	375	1 230
Strimoaia	28	17.4	532	1 745
Sadova	74	46.0	665	2 182
Mestecanis	92	57.2	949	3 113
Tunnel	...	...	948	3 110
Vatra Dornei	108	67.1	789	2 589
Dorna Bridge	116	72.1	813	2 667
Dorna-Candreni	119	73.9	837	2 746
Bridge over the Dornisoara	...	...	897	2 943
Dornisoara	139	86.4	1 032	3 386

The gradients are relatively steep. Between Cacica and Paltinoasa there is 2 517 m. (1.56 miles) of 1 in 34 gradient which is only reduced to 1 in 35 between Sadova and Vatra Dornei, to 1 in 40 between this place and Candreni, and to 1 in 48 between Poiana and Stampei-Dornisoara. The smallest radius of curves is 180 m. (9 chains).

(c) The following altitudes should be added to those given on pages 308/576 and 317/585 (*Bulletin*, March 1936 issue) :

Bucharest North	82 m. (269')
Arad	106 m. (348')
Decebal Frontier	102 m. (335')
Teius	243 m. (797')
Oradea Mare	136 m. (446')
Episcopa Bihar	122 m. (400')
Jimbolia	81 m. (266')

The present position of the development of the microscope and its application to railway service,

by Dr.-Ing. Alfred KARSTEN.

Railway engineering to-day necessitates the testing of numerous kinds of materials, such as steels, bronzes, bearing metals, woods, paints, lubricants, etc., and the study of the phenomena of wear and corrosion, the effects of which must be reduced to a minimum, for which purposes a good microscope is essential. It has for a long time been considered that the microscope has reached its limit of development; higher magnification is indeed scarcely possible, if only for theoretical reasons, and optical lenses can hardly be perfected much further.

Nevertheless, optical instrument designers have succeeded in the last few years in beginning to simplify and quicken micro-photographic work and the change from one system of lighting to another. In the course of experiments conducted with this object, not only have means been found of improving the older methods of illumination but new ones have also been discovered. The exacting and complex conditions microscopes had to meet in metallography, in particular, led to the perfecting of some microscopes known as the camera type, in which a high-power microscope is combined with a camera arranged to take plates of 6.5 × 9.0 cm., 9 × 12 cm. (2 7/16" × 3 1/2", 3 1/2" × 4 3/4") and, for certain special purposes, 13 × 18 cm. (5 1/8" × 7 3/32").

Several types of instruments, having some points of design in common and others different, were rapidly introduced and used, such as the Vickers type II « projection microscope » (fig. 1), the « MeF Universal » camera microscope, made by the Austrian firm of Reichert, and the various German designs, such as the Neophote, Panphote, Orthophote, and the Metaphote, recently perfected and seen in use in figure 2.

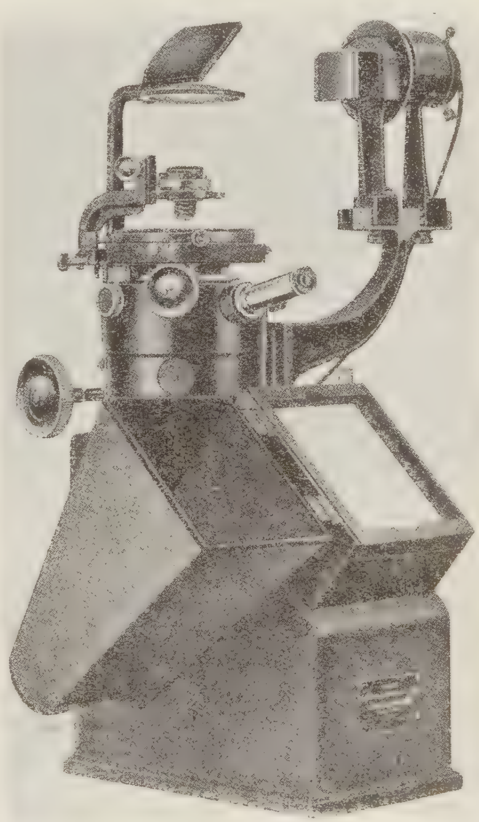


Fig. 1. — Vickers type II projection microscope.

An important improvement characteristic of these instruments is the mounting of the eye-piece tube on a level with the observer's eye, at a favourable angle with the horizontal, allowing of lengthy investigations being made without the tiring bending forward of the head, necessary with older designs. In the Neophote instrument the sloping optical tube, so much used before, has been retained, but in an improved form, which by means of 4 oscillatory socket bearings, has eliminated the principal disadvantage of such an arrangement, namely its sensitivity to disturbances causing the instrument to get out of center or out of adjustment. To enable the instruments to be handled easily and simply it has been found advantageous to incorporate the camera in the modified base casting, as in the « MeF Metaphote » arrangement. This saves space on the work table and eliminates accessory parts from the neighbourhood of the base of the instrument, so that the operator's hands are left quite free.

Fig. 2. — The Metaphote being used with vertical illumination.

The most important improvements in the Metaphote instrument, designed in the experimental laboratory of Emil Busch Ltd., Rathenow, Berlin, are the following : — Construction of the optical system so as to permit of simultaneous observation by the operator and the taking of a micro-photograph, so that the most favourable moment for a photograph can be selected; replacement of the rotating objective carrier by a patented inclined slide frame, in which several objectives may be inserted successively, all being accurately centred.

We may now usefully give some of the results obtained with modern camera microscopes when examining materials used in railway work. Figure 3 is a series of views showing the influence of the carbon content on the properties of steel. In the upper image on the left, etched with picrid acid, magnified 360 times (240 in the illustration), taken with a fine grain medium sensitivity plate, the pearlite areas are discernible among the iron crystals. Carbon content in this case was 0.5 %. Above on the right is seen a test piece containing 0.95 % of carbon, and it shows the uniform texture of the grey cast metal, almost purely pearlitic, with a small amount of graphite. This specimen was also etched with picric acid, and magnified 900 times (600 in the figure). The example below on the left, similarly treated and enlarged, shows hard, white cast metal, the carbon content being 2.9 %, and shows how the crystals of iron carbide have formed in

Magn. × 240) (Magn. × 600)

(Magn. × 600)

ig. 3. — Micrographs of polished test pieces of steel with different carbon contents.

(Magn. × 250)

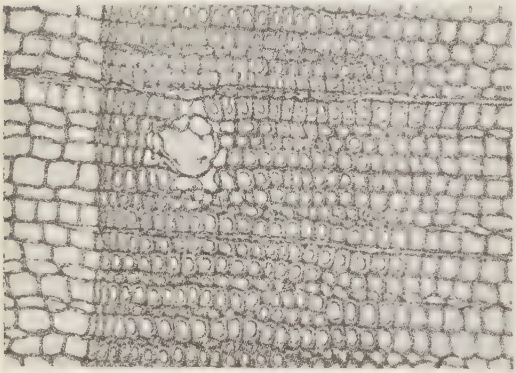
Fig. 4*a*. — Copper protoxide in bright field.

larger groups. Below, on the right, we see a specimen of malleable cast metal etched with chloride of iron, enlarged as in the last two cases. The darkest portions are graphite, liberated during the annealing of the material, surrounded by the decarbonised zone, i.e. the crystals of ferrite limited by the initial pearlitic structure. Figure 4*a* shows a preparation of protoxide of copper, photographed with vertical bright field illumination, such as can be obtained in testing copper for locomotive fireboxes; figure 4*b* shows the same preparation photographed with dark field illumination; both these were magnified 300 times (250 in the illustration). Figure 5 shows a cross section of pine wood illuminated transversally and magnified 130 times (90 in the figure). Experience proves that enlargements may be reduced in scale in proportion as the lighting is more perfect, with the advantage that the exactness of reproduction and the discovery of the characteristic features of the materials examined are markedly facilitated.

As a source of light, low-voltage lamps are now generally used, mounted in a cylindrical metal case with an aspherical condenser and iris shutter. Either a 30-watt (6 volt, 5 amp.) or a 50-watt (6 volt, 8.3 amp.) lamp is used. If they do not give sufficient light, a d.c. arc lamp, 4.5 to 6 amp., is added to the instrument and combined with it on a common base. When it is necessary to make investiga-

(*Magn.* × 220)

Fig. 4b. — Copper protoxide in dark field.

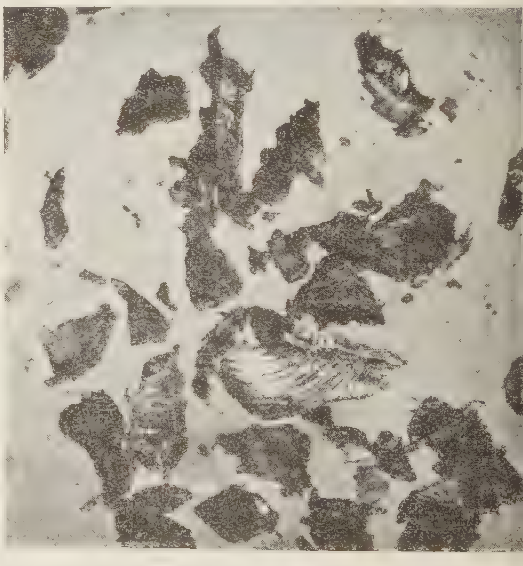


(*Magn.* × 90)

Fig. 5. — Cross section of pine wood.

tions under ultra-violet light, as in the case of lubrifiants and anti-rust paints, the arc lamp is replaced, either by a quartz lamp in the case of special analyses, or an arc lamp fitted with special electrodes, which produce a light rich in ultra-violet rays.

A method of lighting particularly useful in certain cases is that invented by Dr. HAUSER, which consists in illuminating the upper part of the object by transverse light carefully calculated to make its contours appear distinct, and to produce, by simultaneously applying light vertically or obliquely, a high degree of contrast, unobtainable by other means, and a considerable plastic of the image. Figure 6 shows the effect of the HAUSER method of lighting when applied to iron filings, magnified 30 times. A photograph of this kind enables even the kind of file used to be identified. This system of lighting is obtained without any difficulty by using the apparatus shown in figure 7, which shows all the equipment required for obtaining transparent effects, including the lamp container, the deflecting mirror, mounted on a fixed bar and adjustable accurately in a metal chamber, as well as a large Abbe lighting unit fixed on a column which can be secured to the top of the microscope by a simple movement of the hand by means of a so-called « dovetail » slide piece, and



(*Magn.* × 30)

Fig. 6. — Iron filings in Hauser illumination.

removed with equal facility. Between the lamp case and the deflecting mirror there is room for a cooling trough and 2 light filters (red, orange, yellow, yellow-green, blue-green, and blue), 6 × 6 cm. (2 3/8" × 2 3/8"), necessary for photographing

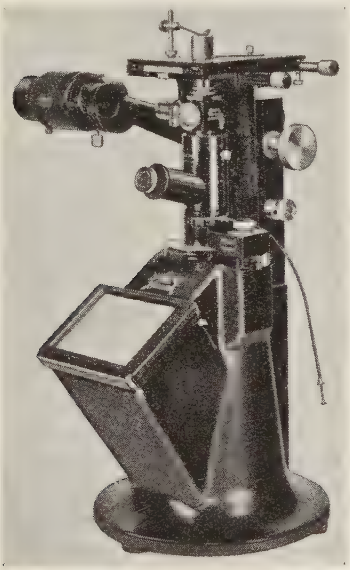
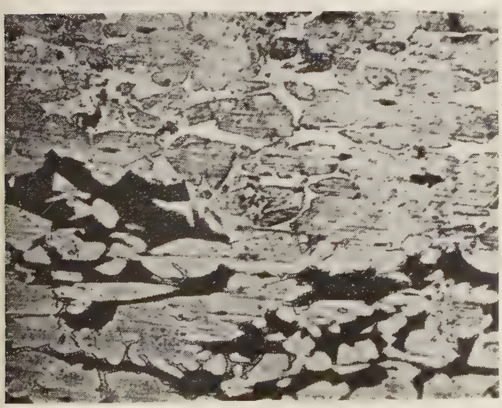


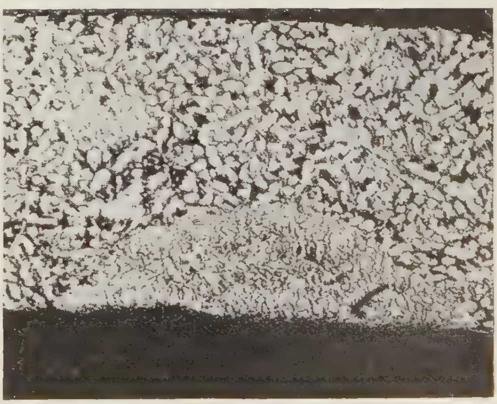
Fig. 7. — The camera-microscope with accessory attachments for Hauser illumination.

coloured objects. The lamp case for lighting from above is held by a transverse arm on a level with the vertical illuminator so that the light arrives on the latter in a direct line and passes thence to the objective. The method of working is to use the well known pattern of bright-field vertical illuminator, or with a new type for either bright-field or dark-field illumination, with prisms, plane plates, and dark-field mirror, known as the « Univertor ».

The modern method of lighting from above is particularly important and useful when studying the phenomena of corrosion. For example, figure 8 shows corrosion in a brass condenser tube ($\alpha + \beta$) such as is often made use of for reasons of economy. This figure, magnified 40 times, shows that in this 2-phase brass, 60.12 % copper and 39.88 % zinc, the inferior constituent is first transformed electrolytically and eventually freed by the superior constituent. The microscopic examination of the phenomena of wear is effected somewhat differently, surface structures which follow a determinated direction then being ob-



(a) Longitudinal section.



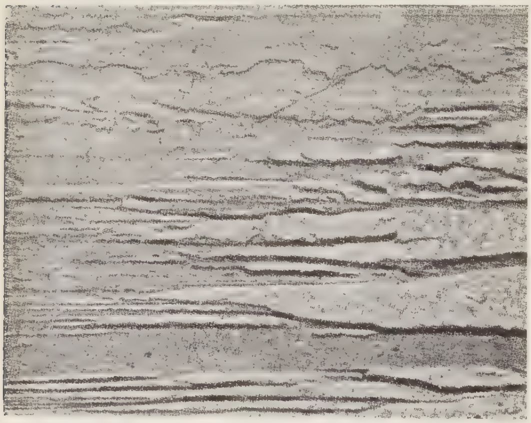
(b) Cross section.

Figs. 8*a* and *b*. — Corrosion on a brass condenser tube.

(Magn. × 40)

served, as in the case of bearing metals, worn shafts, etc. In such cases images rich in contrast are obtained by means of an oblique illuminator, producing concentrated unilateral incident rays, which can be screwed on the microscope. Figure 9 is a specimen of bearing metal with lead content (magnified 12 times); after working for a long time at a temperature of 180° C. (356° F.) the eutectic mass has been pushed outwards in threads, without the crystals of antimony and tin, themselves cubic in shape. The structure at the surface has become quite distinct after treatment with diluted nitric acid.

Almost all modern camera microscopes are fitted with attachments to allow of working with transverse or vertical polarised light and to produce, by means of anastigmatic objectives, what are called synoptic images, which are macrophoto-



(*Magn.* × *12*)

Fig. 9. — Corrosion of a bearing with lead content. Eutectic mass driven out.

graphs of small enlargement. By the simple addition of a system of mirrors, it is also possible to make drawings on a drawing board placed beside the instrument. Such images and drawings are often useful for lecture and demonstration purposes, as well as for keeping records of investigations.

The best camera microscopes, however, can only give the best results when care is taken to employ the most suitable photographic plates and the developer which the tests made by plate manufacturers show to be best adapted to them. For railway work fine grain plates not too sensitive are generally the most suitable, their silver grain allowing of considerable enlargement in the making of the positive. An arrangement that can be recommended is to use photo-mechanical plates, with an anti-halo screen, or diapositive plates and a blue or blue-green filter, the time of exposure being correspondingly prolonged. For photographing coloured objects, such as the painted or varnished surfaces of metals or wood, fine grain medium sensibility orthochromatic plates may usefully be employed. High sensibility (instantaneous) plates, necessary for taking moving or changing objects, are hardly called for in railway work.

In the case of more or less transparent objects, notably detached films of varnish, new or used lubricants, etc., photographs often fail to give satisfaction on account of the reflections arising from the bright parts of the surface. In these cases the so called « striæ » method of TOEPLER may be used with advantage. It is based on the phenomena of diffraction and produces images resembling those taken by the dark-field, or oblique, lighting method but differing from the latter in principle. The photographing is done in a purely geometric-optic manner and is successful with only small differences in the co-efficient of diffraction.

All the various processes of dissolving

chemical products, accompanied by the formation of striæ (hence the name) as well as the various stages of the mixing of lubricants or paints with diluting agents, can be rendered visible by the TOEPLER method. Its application is very easy with the Metaphote. By using a spectacle lens as condenser, the image of the screen contained in the lamp cage is formed on the objective. In the middle of this screen another one is fixed, cut out of black paper, its diameter being such that the image of the screen on the objective becomes slightly smaller than the free opening of the latter. By suitably adjusting the objective screen the most favourable conditions for image forming may be obtained.

The development of camera microscopes, so useful to research both in science and industry, might lead to the ordinary old type microscope with vertical eye tube falling into disuse. To prevent this, there has this year been placed on the market a microscope-macroscope camera of original design called the « Citophote », shown in figure 10, combined with an excellent microscope of the old pattern. By means of a clamping attachment the microscope is secured to the heavy baseplate of the « Citophote » and so made secure against vibration or shock. On the rear edge of the base casting there is a hollow column, the back of which carries two tubes for the reception of lamp cases. One lamp, placed in the upper tube, allows of working under vertical illumination, the other, of employing transverse illumination. The use of both together produces the HAUSER effect. The object to be photographed is focused on the ground glass screen of the reflecting-mirror camera, designed for 9 × 12 cm. (3 1/2" × 4 3/4") plates, which is secured horizontally to the end of the column. The ground glass screen may be replaced by one of clear glass on which the adjustment is made with the aid of a lamp. An image of the same size and clearness then appears on the photographic plate and perfectly square with same. The observer then throws over the handle at the top on the right to move aside the reflecting mirror attachment and open the path for the light rays to reach the plate placed on the rear wall of the camera. The required lighting is then obtained by actuating the catch gear of the time and instantaneous exposure mechanism, on the front face of the camera.

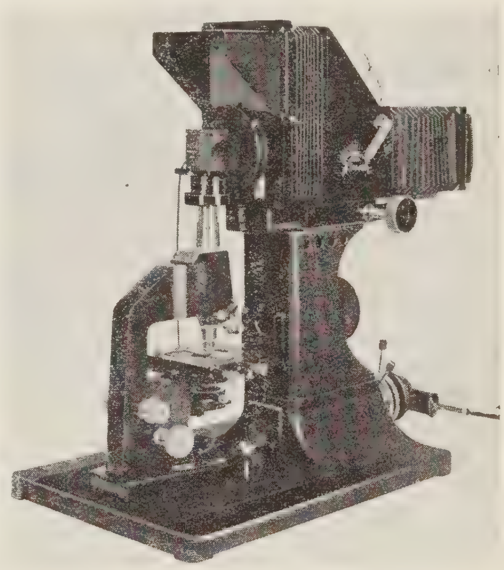


Fig. 10. — The Citophote.

The development of modern microscope technique has taken place at such a rate — faster indeed than that of the present high-grade photographic appliances — that many scientific men are acquainted with only part of the advantages offered by present-day instruments.

Without laying claim to give a complete account of the question, the above remarks from an experienced microscopist will serve to direct attention to the advantages obtainable from the use of the microscope.

* * *

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[625. 143. 5 (.492)]

Method of securing cast iron chairs to pine sleepers on the Netherlands Railways N. P. 46 track,

by A. A. TAK,
Inspector, Permanent Way Department, Netherlands Railways.

The Netherlands Railways have laid their main lines, since 1912, with N. P. 46 track (see fig. 1) (N. P. = standard section), the rails weighing 46 kgr./m. (92.7 lb. per yard) and being carried on cast iron chairs independently secured to the sleepers. The rails are held down on the chairs by two bolts and clips, and the chairs are fastened to the sleepers by four coachscrews. On straight lengths and curves exceeding 500 m. (25 chains) radius, pine (pinus sylvestris) sleepers are used, but on sharper curves, hard wood (oak or beech). These sleepers are 2.60 to 2.70 m. (8' 6 11/32" to 8' 10 5/16") long, their section being 15 cm. × 25 cm. (6" × 9 7/8").

A hard-wood ferrule is driven in for the coachscrew holes in the chairs and suitably fills the space round the neck of the coachscrew; this prevents any movement of the chairs, and at the same time keeps out any water and protects the sleeper from deteriorating.

The large area of the chairs (about 630 cm^2 = 97.6 sq. in.) reduces the destructive action of the trains passing over them.

Although this track is very strong, a large number of coachscrews were found to be loose, having stripped the threads in the sleepers and consequently were not held in the chairs. In the case of the thinner sleepers known as the 5-inch (127 mm.) which were used at one time for economy, the explanation was easily found to be in the failure to use shorter coachscrews; actually some of the coachscrews projected through the sleepers into the ballast. Under the action of the rolling loads, they were driven upwards, and so destroyed their hold in the sleepers.

In the case of sleepers of ordinary thickness (the 6 inch = 152 mm.), when this occurred, as it did in some newly laid sleepers, this reason did not apply, and the cause had to be sought in some disagreement between the following factors : strength of the wood under moving loads, shape and dimensions of the thread of the coachscrews, and the force exerted when driving these coachscrews into the sleeper.

As pine sleepers are chiefly used for this track, and as it is essential that the chairs be fastened down effectively to get a long life from the sleepers, it was very important from a financial point of view to get the correct balance between these factors so as to be able to decide how an improvement could be effected.

As a result of these observations, Mr. Ch. H. J. Driessen, the Chief Permanent Way Engineer, decided to carry out the trials a description and the results of which are given hereafter.

The first thing to be done was to find out the stress that could be imposed on

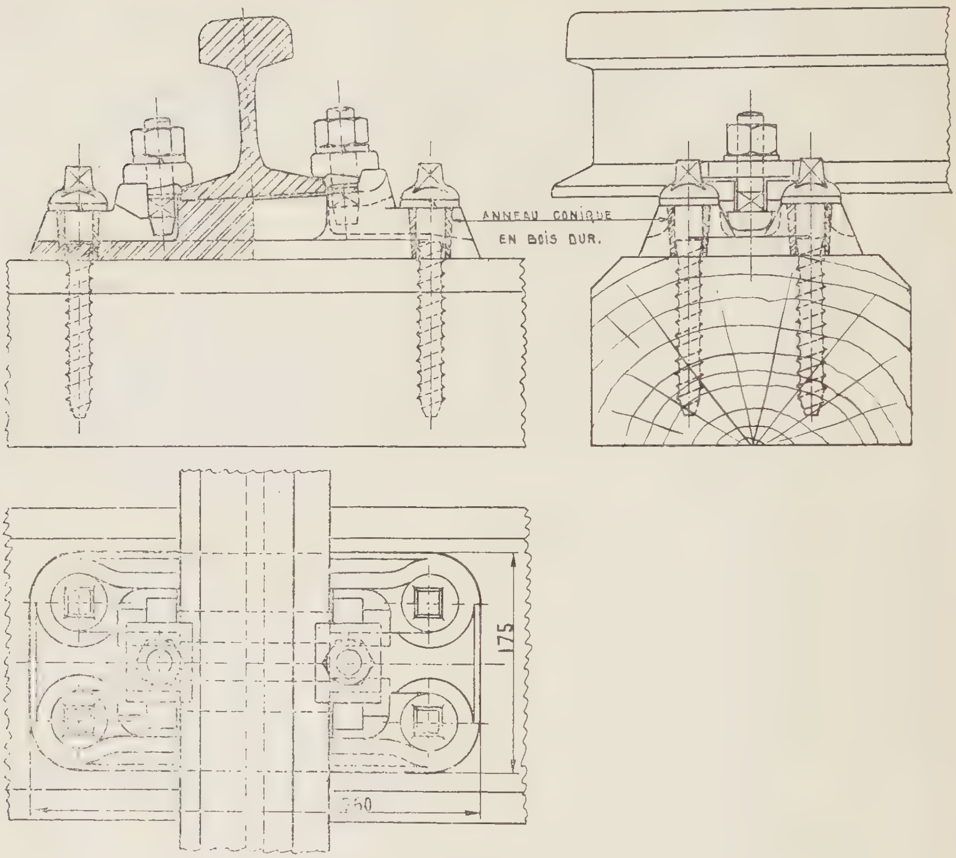


Fig. 1.

Note. — Anneau conique..... = Cone-shaped hard wood ferrule.

a coachscrew with an ordinary spanner and then the force required to strip the thread in the wood.

The coachscrews are generally tightened up by two platelayers using the spanner illustrated in figure 2. They could also be tightened by one man, but the effort would be too great for continuous work, and there would be the danger of the screws not being tightened up sufficiently. Obviously the work can be done more easily by two men; then too, whilst doing the work the men work in balance, which prevents the spanner slipping.

In order to measure the force applied, a special spanner was made; the force applied to the arms is transmitted to the shaft throught two dynamometers shown in figures 3 and 4. The fingers of these dynamometers displace a small block by pushing it along a scale graduated in kilogrammes. When the finger comes back from the position indicating the

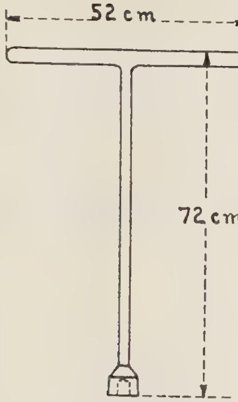


Fig. 2.

maximum force applied, the block in question remains in place and records

Fig. 3.

the said force. As the length of this arm is known (30 cm. = 12"), the moment exerted is deduced at once. The greatest moment exerted by two men was found to be about 6400 kgr./cm. (5 568 in./lb.). In ordinary working the maximum is 4 000 kgr./cm. (3 480 in./lb.).

The force required to strip the threads was then ascertained, in the case of the standard Netherlands Railways' coachscrew which is 23 mm. (29/32") in diameter and 190 mm. (7 1/2") long, and it was found to be 3 000 kgr./cm. (2 610 in./lb.). (In the case of pine sleepers the holes are drilled with a 13 mm. = 33/64" drill).

Two men therefore exert a moment exceeding the latter. Usually the men appreciate when the coachscrew is driven home; of course many a coachscrew may be driven too far and be turning loose in its hole.

Fig. 4.

Obviously the moment exerted could be reduced by shortening the arms of the spanner, but this implies the condition that the spanner still be satisfactory for other purposes, such as driving coach-

screws into hard-wood sleepers (oak and beech).

After considering various other means of reducing the moment, a total length of the arms of 45 cm. (17 11/16") was selected instead of 52 cm. (20 1/2"). The moment is reduced proportionally, i. e. to $\frac{45}{52} \times 4\,000$ kgr./cm. = about 3 450 kgr./cm. (3 000 in./lb.).

Shortening the arms had thus already given one result; there was still the question of improving the thread of the coachscrew by using another shape. With this object, tests were made to see how the Netherlands Railways' coachscrew thread compared with those of other railways, for example the London & North Eastern and the Reichsbahn, both using coachscrews to anchor the chairs or bearing plates to pine sleepers.

As is known the Reichsbahn uses coachscrews in its new track equipped with « Rippenplatten » (ribbed bearing plates) which are very like our chaired road in use since 1912, without showing the same advantages as regards the rigidity of the plate (steel instead of cast iron), the large bearing surface, transverse immobility (through using conical wood ferrules) and the centre bearing.

A number of new shapes of large thread and then a wide pitch thread were examined. This latter was based on the fact that the coachscrew would be most difficult to drive if it had vertical threads. These coachscrews, however, had to be hammered into the sleepers instead of being screwed in. The difficulty of forcing such coachscrews therefore was obtained at the expense of their resistance to pulling out. This idea might, however, be followed up by trying a wide pitch thread.

To increase the resistance a double thread was tried, there being enough space between the threads for this purpose.

We have consequently compared the seven forms of thread shown in figure 5 :

1. *L. N. E. R.*
2. *Reichsbahn*
3. Large sharp thread
4. Large blunt thread
5. Simple wide pitch thread;
6. Double wide pitch thread;
7. Netherlands Rys.' thread (N.S.).

In carrying out these comparative trials, all the coachscrews were the same length, and their heads had the same shape. So as to limit as much as possible the effect of any lack of homogeneity in the wood of any one sleeper, the coachscrews were driven as shown in figure 6. The number over and below the points indicate the type of coachscrew used.

The holes were drilled 2 mm. (5/64") smaller in diameter than the stem of the coachscrew.

There were four series of seven holes in each sleeper; each coachscrew was therefore represented four times.

The table below gives the moments recorded for two sleepers; those for the tightened-up coachscrews cannot be taken as absolute, as the moment the coachscrew is tight depends on the appreciation of the workman, but as this is always so, these figures have nonetheless a comparative value.

	Type of thread.	1st set of holes		2nd set of holes		3rd set of holes		4th set of holes	
		tightened at kgr./cm. *(in./lb.)*	thread stripped at kgr./cm. *(in./lb.)*	tightened at kgr./cm. *(in./lb.)*	thread stripped at kgr./cm. *(in./lb.)*	tightened at kgr./cm. *(in./lb.)*	thread stripped at kgr./cm. *(in./lb.)*	tightened at kgr./cm. *(in./lb.)*	thread stripped at kgr./cm. *(in./lb.)*
Sleeper No. I.	1	1 860 *(1 611)*	2 010 *(1 741)*	1 860 *(1 611)*	1 950 *(1 689)*	1 770 *(1 533)*	2 100 *(1 819)*	1 890 *(1 637)*	2 340 *(2 644)*
	2	1 830 *(1 585)*	2 400 *(2 078)*	1 800 *(1 559)*	2 180 *(1 888)*	1 980 *(1 714)*	2 670 *(2 312)*	2 040 *(1 767)*	2 490 *(2 156)*
	3	2 160 *(1 870)*	3 030 *(2 624)*	1 680 *(1 455)*	3 540 *(3 066)*	2 100 *(1 819)*	3 390 *(2 936)*	2 280 *(1 974)*	3 330 *(2 884)*
	4	2 220 *(1 922)*	2 940 *(2 546)*	1 840 *(1·593)*	3 000 *(2 598)*	1 860 *(1 611)*	2 610 *(2 260)*	2 010 *(1 741)*	3 030 *(2 624)*
	5	2 100 *(1 819)*	3 300 *(2 884)*	2 130 *(1 844)*	3 000 *(2 598)*	2 160 *(1 871)*	3 180 *(2 754)*	2 400 *(2 078)*	2 970 *(2 572)*
	6	2 730 *(2 364)*	3 150 *(2 728)*	2 280 *(1 974)*	3 000 *(2 598)*	2 190 *(1 897)*	2 520 *(2 182)*	2 460 *(2 130)*	3 000 *(2 598)*
	7	2 070 *(1 792)*	2 850 *(2 468)*	1 860 *(1 611)*	2 460 *(2 130)*	1 890 *(1 637)*	2 460 *(2 130)*	2 280 *(1 974)*	3 000 *(2 598)*
Sleeper No. II.	1	2 370 *(2 052)*	2 400 *(2 078)*	1 890 *(1 637)*	2 130 *(1 845)*	1 710 *(1 481)*	2 010 *(1 741)*	1 560 *(1 351)*	1 830 *(1 585)*
	2	2 400 *(2 078)*	3 000 *(2 598)*	1 890 *(1 637)*	2 490 *(2 156)*	1 800 *(1 559)*	2 070 *(1 793)*	1 650 *(1 429)*	2 070 *(1 792)*
	3	2 430 *(2 104)*	3 070 *(2 659)*	2 130 *(1 845)*	3 060 *(2 650)*	1 830 *(1 585)*	2 760 *(2 390)*	1 710 *(1 481)*	2 550 *(2 208)*
	4	2 310 *(2 000)*	2 910 *(2 520)*	2 280 *(1 974)*	2 760 *(2 390)*	2 130 *(1 845)*	2 700 *(2 338)*	1 740 *(1 507)*	2 340 *(2 026)*
	5	2 460 *(2 130)*	3 000 *(2 598)*	2 100 *(1 819)*	2 730 *(2 364)*	1 950 *(1 689)*	2 520 *(2 182)*	1 950 *(1 689)*	2 340 *(2 026)*
	6	2 760 *(2 390)*	3 270 *(2 832)*	2 670 *(2 312)*	3 270 *(2 832)*	2 340 *(2 026)*	2 670 *(2 312)*	2 370 *(2 052)*	2 760 *(2 390)*
	7	1 830 *(1 585)*	2 430 *(2 104)*	2 710 *(2 347)*	2 310 *(2 000)*	1 860 *(1 611)*	2 070 *(1 793)*	1 650 *(1 429)*	2 100 *(1 819)*

The mean values are :

Type of thread.	No. I sleeper				No. II sleeper				For both.			
	tightened at		turning loose at		tightened at		turning loose at		tightened at		turning loose at	
	kgr./cm.	in./lb.	kgr./cm.	in./lb.	kgr./cm.	in./lb	kgr./cm.	in./lb.	kgr./cm.	in./lb.	kgr./cm.	in./lb
1	1 800	1 558	2 100	1 819	1 880	1 628	2 090	1 810	1 840	1 593	2 100	1 819
2	1 910	1 654	2 440	2 113	1 940	1 680	2 410	2 087	1 930	1 671	2 430	2 104
3	2 060	1 784	3 320	2 875	2 030	1 758	2 860	2 477	2 050	1 775	3 090	2 676
4	1 980	1 715	2 900	2 511	2 120	1 836	2 680	2 321	2 060	1 775	2 790	2 416
5	2 200	1 905	3 110	2 693	2 120	1 836	2 650	2 295	2 160	1 871	2 880	2 492
6	2 420	2 096	2 920	2 529	2 540	2 200	2 990	2 589	2 480	2 148	2 960	2 563
7	2 030	1 758	2 690	2 330	1 760	1 524	2 230	1 931	1 900	1 645	2 460	2 130

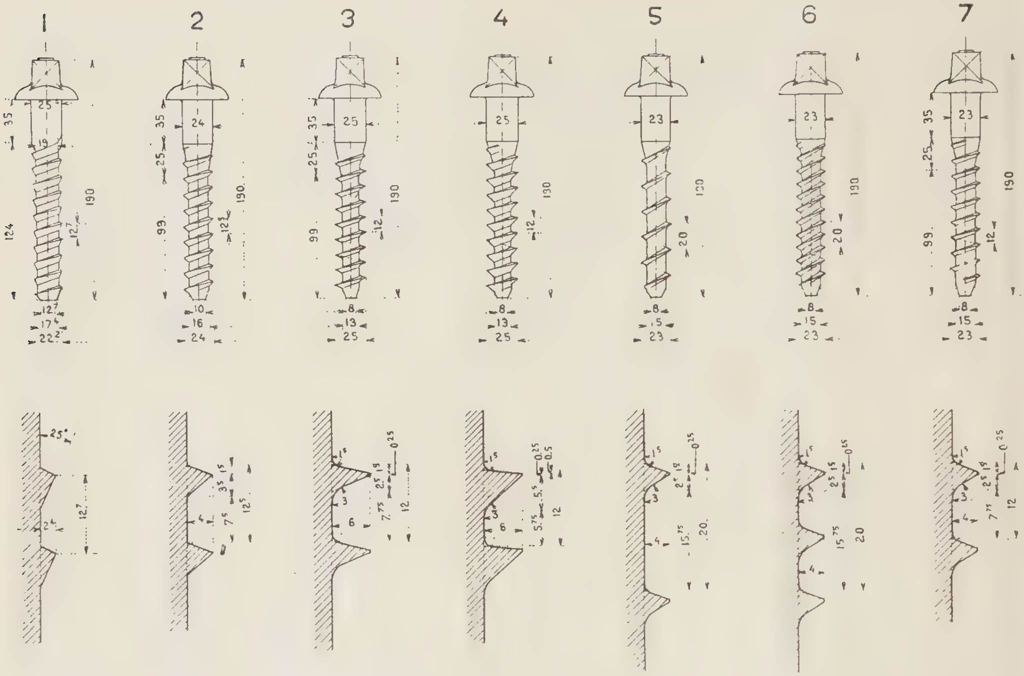


Fig. 5.

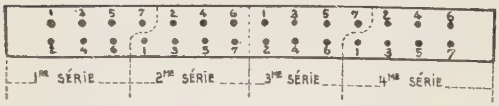


Fig. 6.

As regards their resistance to turning loose in the holes, the average values gave the following classification :

Large sharp thread;
Double wide-pitch thread;
Single wide-pitch thread;
Large blunt thread;
Netherlands Rys.' thread;
Reichsbahn thread;
L. N. E. R. thread.

The test had shown that coachscrews with large sharp threads could not be used, as in driving them into the sleepers too much of the wood was cut away. This type of thread therefore cannot be considered.

The next is the double wide-pitched thread which gives an average value 20 % higher than that of the Netherlands Railways; the trials having been carried on, this thread retained its position.

Tests had to be made, however, to see that its resistance to being pulled out had not been reduced too much.

A tensile test was then made. The sleeper was fastened to the lower table of the testing machine (fig. 7), the top jaw on the moveable upper table gripping the head of the coach screw. When the load was applied, the top table did not move until the force was sufficient to tear out the screw, this load being read on the gauge on the right of the machine (fig. 8).

As was expected, the force required to pull out the screw with the new thread was lower (11 % less). This drawback, however, was counterbalanced to a large extent by the greater force required to strip the threads in the sleeper.

The pulling-out resistance has been adequate all along, and seeing thin sleepers will no longer be used, it will be possible to use longer coachscrews which will make good the said reduction and in addition increase the force required to strip the threads.

Pulling out resistance.			
N.S. coachscrew N° 7 (ordinary thread).		*No. 6 coachscrew* (double wide pitch thread).	
kgr.	*lb.*	*kgr.*	*lb.*
3 060	6 746	2 680	5 908
2 960	6 525	2 820	6 217
2 780	6 128	2 350	5 180
2 620	5 776	2 980	6 570
2 980	6 570	2 660	5 864
2 900	6 393	2 260	4 982
3 580	7 892	3 220	7 099
3 500	7 716	2 700	5 952
3 440	7 584	2 920	6 437
3 380	7 451	3 040	6 701
Average.		*Average.*	
3 120	*6 878*	*2 763*	*6 091*

The result of the enquiry is firstly that the coachscrews must be tightened with spanners having arms not exceeding 45 cm. (17 11/16") in length as a whole, and secondly that the chairs be screwed to pine sleepers with double-thread wide-pitch coachscrews. We may now expect freedom from coachscrews which turn loose in their holes.

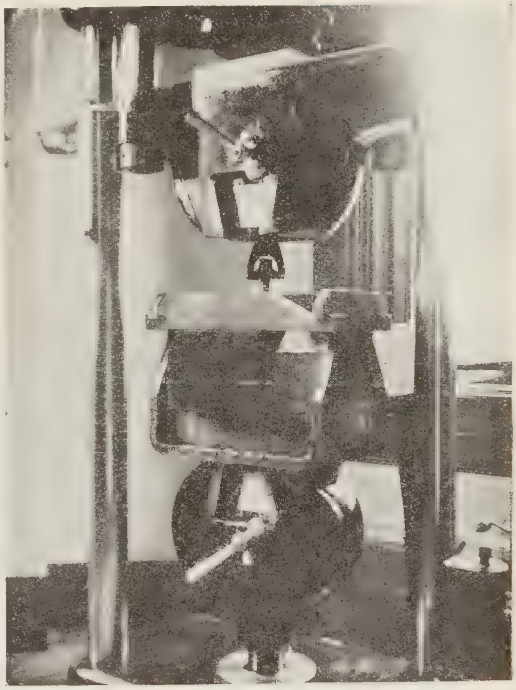


Fig. 7.

Something should still be said about the way defective holes in sleepers were repaired.

As it is unusual for all the four coachscrews holding down a chair to turn loose in their holes, a method of repairing them without removing the chair was looked for. After several trials the following process was selected :

First of all the wood ferrule was withdrawn from its seat by a kind of corkscrew, illustrated in figure 9. The damaged hole was then opened out with a 24-mm. (15/16") drill.

A cylindrical sleeve in hard wood was then driven into the chair with the steel drift shown in figure 10. So that the sleeve can be driven without splitting it, it is screwed unto the end of the conical threaded drift, and consequently is held

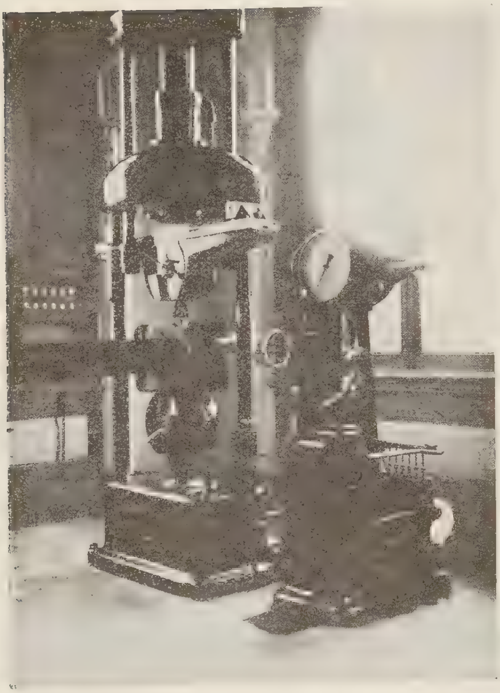


Fig. 8.

30-amp. 240-volt generator, on a 2-wheeled truck which can be moved along the track.

Each set has in addition an electric drill and an electric coachscrew driver. The cable connecting the generating set to the drill and coachscrew driver is

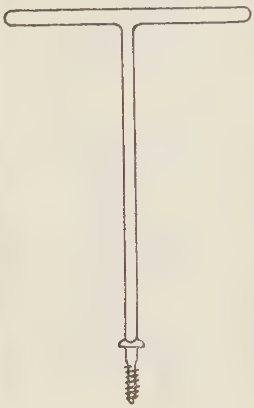


Fig. 9.

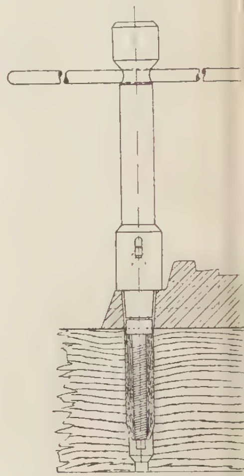


Fig. 10.

over its whole length. Once the sleeve is driven home, the drift is withdrawn. A new hard-wood ferrule is then inserted into the hole in the chair and the coachscrew is then screwed home. If the old coachscrew is not too long, and its thread not rusted away, it can be used again.

As the number of holes was too great to be repaired by hand, a few electrically-driven plants were obtained, each set consisting of a petrol engine driving a 40 m. (131') long, so that four 18-m. (59' 5/8") rails can be dealt with without moving the set.

On finishing one length the next 40-m. length is taken in hand. In this way 600 to 800 holes can be repaired per day.

Whilst carrying out this work it was found uneconomical to repair the holes mechanically if less than 15 % of the total number were damaged, i. e. manual work was found cheaper.

[621. 135 (01, 625. 14 (01 & 625. 22]

The relation between track and rolling stock. (*)

A discussion of the trends in track construction and the effects thereon of locomotive and car design,

by Dr. Arthur N. TALBOT,

Professor Emeritus, University of Illinois, and Chairman, Joint Committee on Stresses in Railroad Track of the American Railway Engineering Association and the American Society of Civil Engineers.

(*Railway Age.*)

Track is a flexible and elastic structure. Under the loads of locomotive and car wheels the rail bends, the wood of the tie under the tie plate compresses and there is bending lengthwise of the tie, the ballast and roadbed under and between ties compress so that in addition to movement due to the play or free space between tie and rail there is a downward movement of the rail which is called the rail depression (an important element in the analytical treatment

Test party and train crew conducting test with electric locomotives. Dr. Talbot is the third man from the left.

of the problem). The « rail depression » at some distance from the nearest wheel may be upward (negative), giving rise to the common expression « wave motion ». The unloaded rail quickly rises to its original position — the whole structure in good track is « elastic », for very many applications of load are required to give appreciable permanent depression to the track.

The Stresses in Track investigation, in its first report, developed a mathematical analysis for calculating the stresses

(*) A paper prepared for presentation before a joint meeting of the Western Railway Club and the American Railway Engineering Association at Chicago on March 17, 1937.

in the rail and depressions of the rail at points at and near the wheel loads which may be applied to any given grouping and spacing of the wheel loads of a locomotive or coupled cars for given conditions of the stiffness of that part of the track structure below the rail, as measured by the « modulus of elasticity of rail support ». Under assumed conditions of track and loading the stresses and depressions calculated by means of this analysis are known to be substantially correct. The interpretation of analyses and tests have resulted in many findings of interest and value. Some of them will be mentioned in what must be a hap-hazard and incomplete way.

So far as stresses in rail are concerned, one important fact was early established — that the maximum bending stresses in rail under the loads of closely spaced wheels (like the driving wheels of a Mikado locomotive or the truck wheels of two closely coupled freight cars) are considerably less than the stresses that would be produced by a single wheel load like that of a trailer that is well away from another wheel. Please remember, however, that this decrease applies only to the so-called bending stresses. The bearing stresses in the rail under the wheel (stresses which are related to the stresses tending to develop transverse fissures) are not particularly affected by this reduction in bending effects, and these bearing load effects tend to control or limit the maximum desirable wheel load. It may be remarked that in other ways too the ordinary bending stresses in the rail under steady vertical pressures may not govern the limiting wheel loads for good track.

Depression of rail and stiffness of rail support.

A property of track which has not received adequate attention in discussions is the stiffness of the rail support; that is, its resistance to depression or downward movement under the application of loads on the rail. This property and the shape of the depression curve throughout the length of the locomotive and under and between the trucks of cars, as determined by the magnitude of the wheel loads and their spacing along the track, tell an important story of the way in which the track has received the load and the possible punishments that may be applied to it, and may suggest or reflect the reacting relation on the rolling stock above it.

The magnitude of this depression of the rail support is not large on the best track — is not even as great as it appears to the ordinary eye as the train goes by. Disregarding the play between rail and tie and taking only the net lowering produced by the loads of an ordinary Mikado locomotive, the rail will depress say 1/8 inch on a very stiffly built rail support (tie plates, ties, ballast and roadbed) (modulus of 4 000), and similarly it may depress 1/4-inch on an ordinarily well ballasted and well kept track (modulus of 2 000), though of course on a loosely ballasted and poorly maintained track the depression may be 1/2 inch or even considerably more.

It has been found that the maximum depression made by a group of closely spaced wheels is dependent almost solely upon the stiffness modulus of the rail support. Doubling the modulus of elasticity of rail support will halve the amount of the maximum depression. The stiffness of the rail or the size of its section has little effect on the magnitude of the depression of the closely spaced group of wheels. It will have an effect on the depression at a lone wheel such as the trailer, which by itself gives an undesirable form of depression curve, but this may be ironed out very advantageously when a two-axle trailer truck is used.

The shape of the curve of depression

may be said then to be dependent upon the stiffness referred to and to the spacing and grouping of the wheel loads. A grouping of wheels and the spacings might be chosen that would form a smooth regular depression from the first wheel to the last of a group, or they may produce a series of ups and downs along the rail. An approach to the smoothened curve, which may be obtained by suitable wheel spacing in many cases, will be advantageous. It is apparent that the destructive effect of the load on the rail support (effect on the integrity of the tie and ballast as evidenced by necessary track maintenance) will depend in some measure on the amount or magnitude of the up-and-down movement within this structure as each wheel or each group of wheels passes by. The shape of the depression curve (as well as its depth) may possibly affect the tractive resistance somewhat. Other things being equal, then, the greater the stiffness of the rail support, the less the maintenance charges caused by traffic. Solid roadbed, thoroughly compacted ballast, and substantial ties, all put into best line and surface, will contribute to low cost maintenance.

Value of heavy rail.

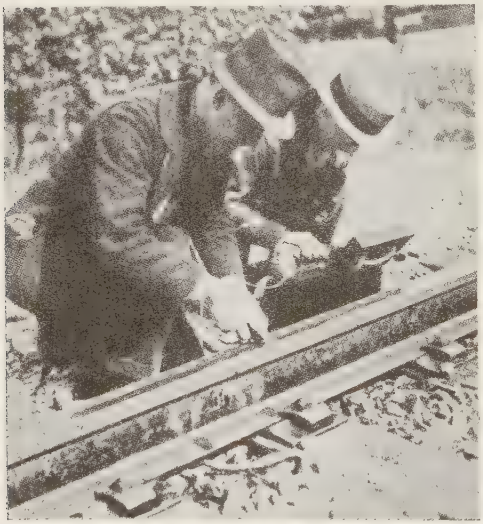
Much interest has been taken by maintenance engineers and executives in the value of increased rail section, heavier rails. What is the source of the advantages of heavier rail? For substantial and well-kept track substructure (still using this expression for ties, ballast and roadbed), a section of rail will be reached when the bending stresses in the rail are reasonably moderate in magnitude for carrying well designed and well maintained rolling stock. I can not take time to discuss the numerical value of these stresses but they are reasonably moderate for medium weights of rail under the conditions named. It is true also that the maximum rail deflections along the group of closely spaced wheels in an ordinary freight train are little affected by increasing the weight of rail, though an accompanying increase in the stiffness of the substructure made at the same time itself will decrease the maximum rail depression approximately inversely to the relative stiffnesses of the supports before and after. So far as I know, little study has been given to the relation between size of rail and the magnitude of bearing stresses on the head of the rail, but between moderate weight and heaviest rails there is probably little difference. Nor do I know of definite and adequate statistics on the rate of wear of rail for different sizes. With the multiplicity of variation in form of worn wheel treads passing over rails of different sizes and ages, an answer to such questions can hardly be expected. Some of the efforts to evaluate the reduction in tractive resistance and the lessened cost of maintenance with increase in rail section are not convincing.

And yet heavy rail must present an advantage to both track and rolling stock. One gain not often mentioned is that added stiffness gives greater ability to carry loads over short soft spots without undue deflection or permanent bending of the rail, at places where the weakness in the substructure may not be apparent. Heavier rail will better resist without so much permanent deformation the lateral impacts and those extra loads and blows that come rather frequently from poorly designed or poorly maintained rolling stock, perhaps of unknown or accidental character. Much of the advantage of heavy rail must be based on a number of such resistances and safeguards.

Heavy rail is not a panacea for inadequate substructure. To obtain the full gain from an investment in heavy rail, the rail support must be correspondingly substantial — closely spaced solid ties, full ballasted and well maintained substructure. The same care, too, must

be taken to secure uniform smoothness and stiffness along the length of the track.

How to evaluate the economy of heavy rail is a baffling question. An attempt to solve it by mathematical methods in the present state of our knowledge involves assumptions and uncertainties and deficiencies in knowledge. Especially must there be difficulties and uncertainties in making a choice of coefficients to translate it into reliable money estimates. A conclusion based on mathematical assumptions (direct or implied) is likely to carry with it implications of certainty not warranted by the nature of the available data or by the accuracy of the assumptions. It can hardly be said to be something on which a heavy investment may be based with any confidence. Definite experience and observation on the results obtained with increased size of rail, both with and without an accompanying improvement in substructure, are greatly needed. With only the information available at the present time, it may be better to rely on the direct judgment of an experienced man who can sense needs of the situation.



Using a thermocouple and a potentiometer to measure rail temperatures on continuously welded rail.

Smoothness vs. variability of surface.

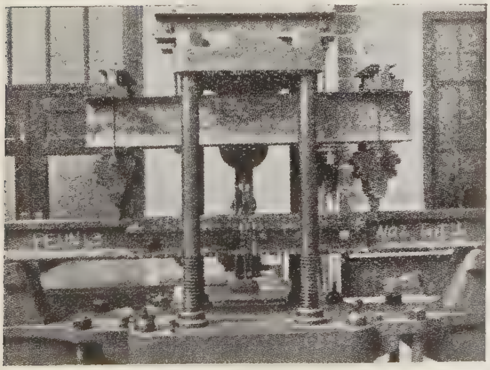
In maintenance work the trackman leaves the surface and line in excellent appearance. I have full admiration for the work of the trackman; he does a good job so far as he can see, but he can not see the condition between rail and tie or under the ties. Unfortunately, what seems a perfect surface in an unloaded state may in the loaded state be made up of uneven supports, reacting variably, so that the effect is that of ups and downs from tie to tie while the train loads are applied. The action of traffic may soon give permanent depression to the poorly supported ties. Under repeated application of the loads of locomotives and cars the depression of the rail becomes irregular from tie to tie. Even seemingly small variations in the adzing of a tie will easily give a twist to the rail and change the position of the application of the reaction between rail and tie. The consequence is that the load taken by adjacent ties as the wheel moves along, especially with a

Test party preparing stremmatographs to measure rail stresses in a test run.

heavy rail, may vary from zero to two or three times the average tie load; the track is in effect made up of relatively soft and hard spots; instead of being smooth, the track supports may be relatively rough; unduly high and unexpected stresses are applied to rail, tie and ballast; maintenance damage is increased by both the excessive vertical loads and the lateral loads thereby applied.

Further, and this is important for high speeds, the variability in the supports is not only from tie to tie — it occurs from spot to spot a few feet or a hundred feet apart. A track that may serve for freight trains at 30 m.p.h. will be unsatisfactory at 60 m.p.h. and more so for a passenger train at 90 m.p.h. or faster. The movements of car springs and car bodies at high speeds will necessarily catch the variations in track at longer distances apart, and uniformity of surface over longer stretches becomes increasingly essential to smooth action as speed increases. It is obvious that the higher the speed the greater the disadvantages caused by variability from one point in track to another.

It should be added that these undesirable variations in track surface when loaded are relatively greater for stiff rail-support than for the less stiff support found in less stiffly ballasted track. A variation from point to point of 0.10 inch is far more damaging with an average rail depression under load of 0.10 inch than when the average rail depression under the same load is 0.25 inch. In other words, on stiffly supported track (that built for heavy and fast traffic) the effect of variation in stiffness and in variable play between rail and tie bed is very large. This means that even greater care to secure uniform support and to avoid the variabilities found by the tests should be used in the maintenance work on heavy traffic track.



Laboratory set-up to find stresses in various parts of rails and joint bars under various loads.

Let me express the view then that one of the findings of the tests is that the appearance of the rail surface in an unloaded state is far from being an indication of the uniformity and smoothness of the supporting structure while loaded and that this unseen variability is an unsuspected source of the lack of smoothness in track. One of the great needs is an improvement in the work of tamping track to insure better uniformity and smoothness of rail support over greater distances. The man who will devise a ready way of measuring track stiffness and its variability and of regulating the tamping well toward uniformity will make a real contribution to track excellence. With machine tamping, there is no indication that uniformity has been much improved. I want to suggest that track engineers should bend their efforts to securing an improvement in uniformity of rail support. The heavier the rail and the stiffer the substructure the greater the need. Success will be worth the effort. Perfection can not be expected but improvement is possible. And after all, careful and adequate maintenance work remains a desideratum in the upkeep of track.

At the risk of some repetition, let me say that the use of stiffer substructure (ties, ballast and roadbed) built for the purpose of carrying heavy traffic a longer time without extensive maintenance

charges carries with it to the management the obligation to construct and maintain a uniformly smooth track (smooth while loaded), free from the variabilities heretofore referred to. This requirement is needed to ensure moderation in train equipment maintenance and smoothness of train operation, as well as to ensure a lessening in track maintenance.

The tests and studies made on the rail-joint problem have produced valuable results. Among the advantages found may be mentioned that accruing to the joint through having an increase in the fishing height of the joint bar made available with the newer rail sections. For the heavier rail sections the shape known as the symmetrical bar or near-symmetrical bar has been shown to have substantial advantages over the angle bar type, though for the lighter rails the advantage is not so marked, but for these lighter rails the information obtained has resulted in a much better design of the angle bar. A moderate bolt tension of 8 000 to 15 000 lb. is considered much better than a higher tension. A still lower bolt tension is not particularly objectionable in a well-fitting symmetrical bar, though it does reduce the effectiveness of the angle bar materially. Excellence of fit between bar and rail (very close fit) is essential to proper joint action, resulting in smaller deflection, larger participation in carrying bending moment, smaller wear, and generally in lessened rail batter.

Continuous welding of rail.

The several stretches of track under observation on the Delaware & Hudson at Albany, N. Y., and Schenectady and Mechanicville, which have the rail ends welded to a continuous length of 1/2 mile to 1 1/2 miles and the mile stretch of the Bessemer & Lake Erie at Pittsburgh, Pa., have now passed through two to four winter seasons with apparently satisfactory results. The staff of the Track Stress investigation has made observations and measurements in warm and cold weather to determine the temperature stresses developed along the length of stretches and the nature and extent of the rail anchorage developed at the end portions of the welded stretches.

Track curvature.

Curvature in alinement has always had its difficulties. The change in direction of a locomotive as it goes around a curve, the pressure and wear on the outer rail to actuate this turning, and the reverse pressure on the inner rail at the pivoting point at or near one of the intermediate drivers act to put large strains and stresses in the rail, those caused by heavy locomotives having been found to be as great at 60 000 lb. per sq. in., and doubtless there are correspondingly large stresses developed in the locomotive. By reason of limitations on the amount of super-elevation permissible, even the lighter curves may limit modern high train speeds (both passenger and freight), though of course it is true that a speed somewhat higher than the normal speed for the superelevation used will give smoother motion for the faster trains, especially if suitable spirals are used to change from tangent to curve and back again. The introduction of high speeds makes it extremely desirable to extend our knowledge of the relation between track and rolling stock for the benefit of the equipment, track maintenance, and train operation.

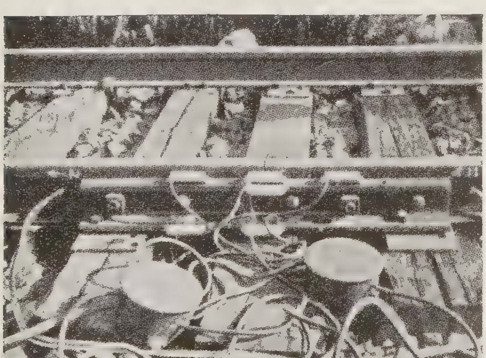
Locomotive counterbalance.

Improper locomotive counterbalance has long been a source of injury to track. The tests of the Track Stress investigation and those of other agencies have uncovered many instances of seriously faulty counterbalance (either by oversight or ignorance in design or unauthorized changes made in repair shops), which have caused serious destructive

damage to rail and other parts of track. Increased weight of driving parts and the seeming need for larger dimensions which have increased the out-of-plane distances between rail and moving parts, together with large increases in operating speeds have made the counterbalance problem a most important one, especially when locomotives have been used at speeds well beyond those for which they were designed. Buying heavier rail does not seem a satisfactory solution for such ills. Fortunately, improvements in design, high-strength materials, larger driving wheels and better opportunity for placing counter-weights, lessened allowance for reciprocating parts and adequate cross balancing have made it possible to equip locomotives with counterbalance that will apply only a reasonable increase in load on the rail, even at the higher operating speeds. The advantages gained extend also to the maintenance of the locomotive itself.

Lateral oscillation.

But the out-of-balance of rotating and reciprocating parts is not the only source in increasing the load on rail at the higher speeds. Electric locomotives as well as steam locomotives are subject to transverse oscillatory or vibratory movements, front and back (the periodicity of the vibration depending upon the dimensions and design or the locomotive and not upon speed). This pendulum-like oscillation may be started by roughnesses in the track (slight roughness or variability if the speed is high), by going on or coming from a curve, or by some action of the locomotive itself. It is well established that a transverse or lateral pressure of a wheel on a rail results in an increase in vertical pressure or load applied to a rail by one wheel and in a decrease in the load applied by the other wheel on the same axle. Lateral pressures on the rail observed in tests, due to these oscillations on straight track, have been extremely large, almost unbelievably great, high enough to move highest-grade track laterally well out of line. Corresponding transfers of vertical loads from one wheel to the other wheel of the same axle may likewise greatly increase the vertical load applied to one rail. Such an extreme case is cited to show difficulties that arise in the use of very high speeds.



Six magnetic strain gages to find stresses in joint bars at speeds up to 90 miles per hour.

Conditions of rolling stock.

Then there are many mooted questions about rolling stock in general — its design, its upkeep, its liability to get out of order. Why do individual wheels of heavily loaded freight cars in ordinary service sometimes show rail stresses equivalent to those of a wheel load of 60 000 lb. when another wheel of the same car gives corresponding wheel loads of 25 000 lb. at the same point in the track, as has been found by the test party of the Rails investigation on regular trains passing over ordinarily good track. What is the cause of such excessive loads? Again, is the standard coning of wheels conducive to unnecessarily large lateral motion, the wheel flanges first bumping against one rail and then the other, and how does the variably worn wheel tread influence this back and forth motion, either at low speeds or at high? Without going over the whole field, does it not seem evident that

there are many questions needing answers that affect the influence of the design and condition of the rolling stock on the upkeep of the track, as well as questions on the effect of the construction and upkeep of track on the design and operation of the rolling stock? Unquestionably there are interrelations between track and rolling stock that merit adequate investigation.

The matter of an investigation on the relation between locomotive and cars and the track and bridges is not a new question. Two of the later efforts may be referred to. In 1931 and again in 1934, acting on suggestions made by officials of the American Railway Association, a conference committee composed of representatives of the Committee of Stresses in Railroad Track of the A. R. E. A. and the Committee on Locomotive Construction of the Mechanical division discussed the needs and advantages of such an investigation.

Quoting in part from the second conference report, « It has become evident to those engaged in the design and operation of railroad rolling stock and the construction and maintenance of track and bridges that there is great need of a thorough experimental investigation on the mutual or interacting causes and effects between the rolling stock and track, which would be expected to establish basic principles and obtain pertinent data on standard track with various forms of rolling stock and which would lead the way to improvements in rolling stock and track and to remedying existing conditions now not fully satisfactory. Further, it is believed that the two instrumentalities (the rolling stock and the track) should be kept in mind and hence that the investigation should be conducted jointly by representatives of the Engineering division and the Mechanical division ».

Topics named included counterbalance, matters of wheel loads and wheel spacing, oscillating characteristics of locomotives and cars, wear of wheels, characteristics of springs and their relation to track and rolling stock, distribution of load among wheels, prevention of excess load on individual wheels, and periodic vibration of cars, all having a relation both to the track and to the car or locomotive. Reference was made to the bridge engineers who have been urging the need for information on the characteristics of modern American locomotives on bridges of different lengths and types.

To quote again, « The effort should be made to establish principles and methods on the interrelation of the locomotives and the cars and the track as affecting pressures and stresses in the rail, ties and ballast and bridges and also the reaction effects on the various parts of the locomotive and cars in so far as these affect design, construction and maintenance ». Expressing the belief that an investigation would result in information of value to the railroads many times greater than the expenditure involved, the conference committee report outlined methods of conducting the investigation, made a preliminary estimate of the expenditures necessary, and recommended that the American Railway Association be asked to authorize an investigation of the interrelation of rolling stock and track.

I am told that both conference reports were looked upon with favor, but the times were not auspicious for the railroads to go into such an undertaking. Perhaps the time is not yet ripe for making a new effort to start this needed research. However, may we not expect (or at least hope) that in the not too distant future such an important research problem will be undertaken under the support of the Association of American Railroads. And may we not believe that whole-hearted cooperation between the Engineering division and the Mechanical division in both the investigation and the mutual utilization of its fruits in their work will be a great gain for the American railroads.

[625. 144.4 (.42) & 625. 172 (.42)]

Measured shovel packing,
London Midland and Scottish Railway.

A development designed to minimise the risk of error in shovel packing.

(The Railway Gazette.)

Although the shovel packing of sleepers, inaugurated on the old L.N.W.R. in 1908, has been in use on many railways for several years, it was left to the engineers of the Northern Railway of France to devise a method of measuring by mechanical means the amount of chippings required to take out a known amount of slack. Previously the experience of the permanent way men was relied upon to judge the quantity of chippings required; but, in measured shovel packing, even the most inexperienced of gangs can be certain of accurate packing. The objection of British engineers to the French method of measuring (*) was that it seemed too elaborate to work well elsewhere. A simplified method is practised on the Buenos Ayres & Pacific Railway (**) and recently another modified system has been successfully adopted by the London Midland & Scottish Railway.

Measured shovel packing by the

Sighting boards on rail ready for use, set closer than necessary to secure picture.

Part of intermediate sighting board, showing adjustment and scale.

L. M. S. R. method is accomplished in three steps. First the sag or dip in the track is measured by the use of sighting boards placed upon the head of the rail. Secondly the depression of the sleepers under a train is recorded on a series of voidmeters; and thirdly the requisite amount of chippings determined in the first two steps is spread under the sleepers.

To measure the extent to which the track is out of level when no traffic is

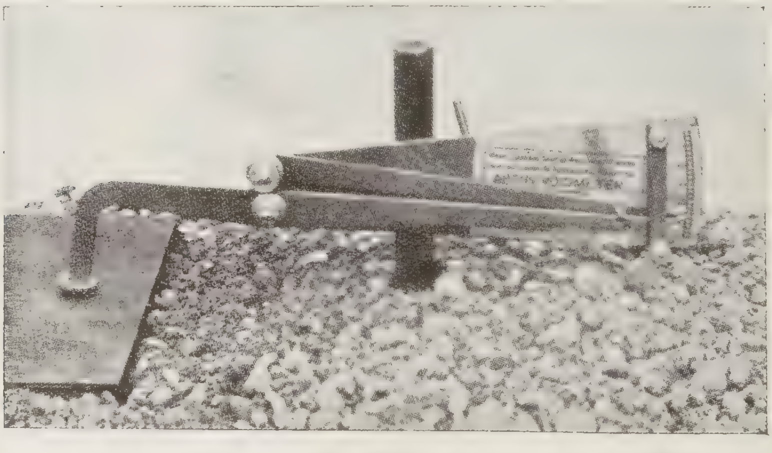
(*) Described in *The Railway Gazette* on July 3, 1931, p. 12, and April 17, 1936, p. 736; and in *The Railway Engineer* of April, 1932, p. 156.

(**) *The Railway Gazette* of May 1, 1936, p. 864.

on it, a set of three special sighting boards or boning rods is used. These boards are fitted to short posts having clips at the bases so that they are readily fixed on the top of the rail. One board is provided with a slit at the level of the eye of a man sitting on the rail; the second or intermediate board is painted half yellow and half black with a vertical division between these colours running down the centre of the board. The post of this intermediate board is adjustable in height and provided with a scale so that the amount of extension required to bring the top of the board level with the eye-slit in the first board is readily determined. The third board is painted with the face divided into four spaces to present a chequered appearance of four rectangles, the yellow and black colours being divided vertically down the centre and horizontally across the board at the same level as the eye-slit of the first board. All three sighting boards are fitted with spirit levels to ensure that they stand perfectly vertical when clipped to the rail.

The ganger sights along the rail in the usual way and locates two high spots preferably not more than 120 ft. apart. The first or eye-slit sighting board is then fixed at one high spot, and the third or target chequered board at the other. The second board is then placed on the rail over a sleeper intermediate between the high spots. The height of this board is then adjusted until the top is level with the eye-slit and the horizontal dividing line between the checks on the board most distant from the observer. The number of divisions revealed on the scale of the intermediate board when it has been raised is then read off and the figure chalked on the sleeper immediately below this board. The intermediate board is then moved over the other sleepers until the amount of « static » slack for all the sleepers between the high spots has been determined. This process is then repeated along the other running rail between the same high spots.

The permanent way gang is supplied with a dozen « voidmeters » for measuring the depression under the passage of a train. Steel bars some 18 inches in length are driven into the ballast about 3 inches from the side of each sleeper and one inch outward from the end of the chair. To each of these bars a voidmeter is clamped at such a height that the bottom of the turned-down end of



Voidmeter set ready for use.

the spring-loaded pointer is in contact with the top of the sleeper and the pointer exactly on one of the lower divisions on the scale. The second or loose pointer is then pushed down so that the projecting pin on it lies on the top of the spring pointer. Passing traffic depresses the sleepers and, with the set of 12 voidmeters, generally six on each side of the track at a time, the tails of the spring pointers in contact with the sleepers move with them, pushing up the upper or friction pointers. Thus, after a train has passed, the two pointers are separated by a distance having a fixed relation to the depression of the sleepers. The number of divisions on the scales by which the pointers on each voidmeter are separated is then read off and the figures chalked on the sleepers.

The sum of the figures obtained for each sleeper by these static and dynamic measurements determines the number of canisters of chippings required to be spread under each sleeper to take out both the depression in the « top » and the void which allowed it to sink under the wheel load.

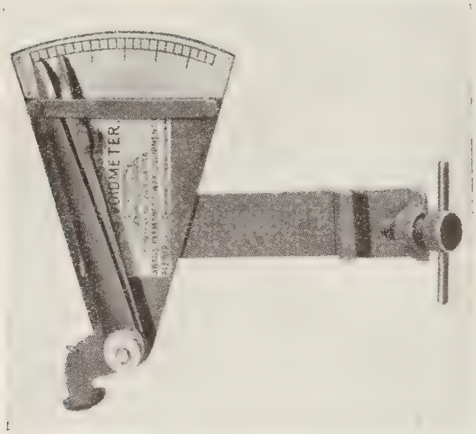
Particular care is taken in using the voidmeters to see that the bars driven into the ballast are reasonably firm so that they will not be moved by the resistance of the pointer spring when traffic is passing. The friction pointer is adjusted so as to be just stiff enough in its movement to follow the spring-loaded pointer and remain at its highest position. A small thumb nut is used for adjustment. A modified type of voidmeter, illustrated overleaf, has recently been evolved and has the advantage, over the original design, of smaller size, and that the scale is easier to read and multiplies the sleeper movement by four.

If the size of the gang permits, the sighting and voidmeter measurements are taken by separate parties, and, under the same conditions, the packing is done by more than one man. In using this method of packing, as with any other, no slack more than one inch combined is tackled at one time, and it is better to keep to half that figure as a maximum and to run over the section again with voidmeters and sighting boards a week or two later.

It is obviously important that the proper size of chippings be used and the size of the canister used on the L.M.S.R. has been based on the use of 1/4-inch minimum to 1/2-inch maximum granite chippings evenly spread over 15 inches on each side of the rail and completely covering the width of the sleeper for that distance. The canister, 3 1/2 inches internal diameter and 4 7/8 inches high is made of 20 S.W.G. lead-covered sheet iron spot-welded. To make this canister a measure for 10 inches as well as 12 inches wide sleepers, short slits are cut 7/8 inch down from the top; for the narrower sleepers it is filled only up to the level of these slits, and for wider

Voidmeters set on sleepers (actually they are usually placed on alternate sleepers).

Left : Chips canister, filled up to slit for 10-in., and full for 12-in. sleepers.
Right : Inserting chippings under the jacked-up sleepers.



Latest type of voidmeter with 4 to 1 scale.

or joint sleepers it is filled flush with the top. The divisions on the scales of both the voidmeters and the intermediate sighting board are in units of canisters of chips and they do not necessarily represent a slack measured in inches, although on the L. M. S. R. each division on the scale represents 1/16 in. of slack.

The actual chip packing must be done by spreading, the track being lifted with a jack designed to fit snugly below the top of the rail and capable of instantaneous release on the approach of a train. The track is raised just sufficiently to permit the clear passage of the packing shovel with its charge under the sleeper. On the L. M. S. the ballast is removed from between every alternate pair of sleepers, and the chippings are spread from one side only of each sleeper, a special goose-neck shaped shovel having a flat blade 6 1/2 inches wide and 8 inches long being used. Care is always taken to ensure that all chair screws and other fastenings are quite tight before taking the measurements for shovel packing.

[621. 43 & 621. 8]

Five-speed Mylius gearbox

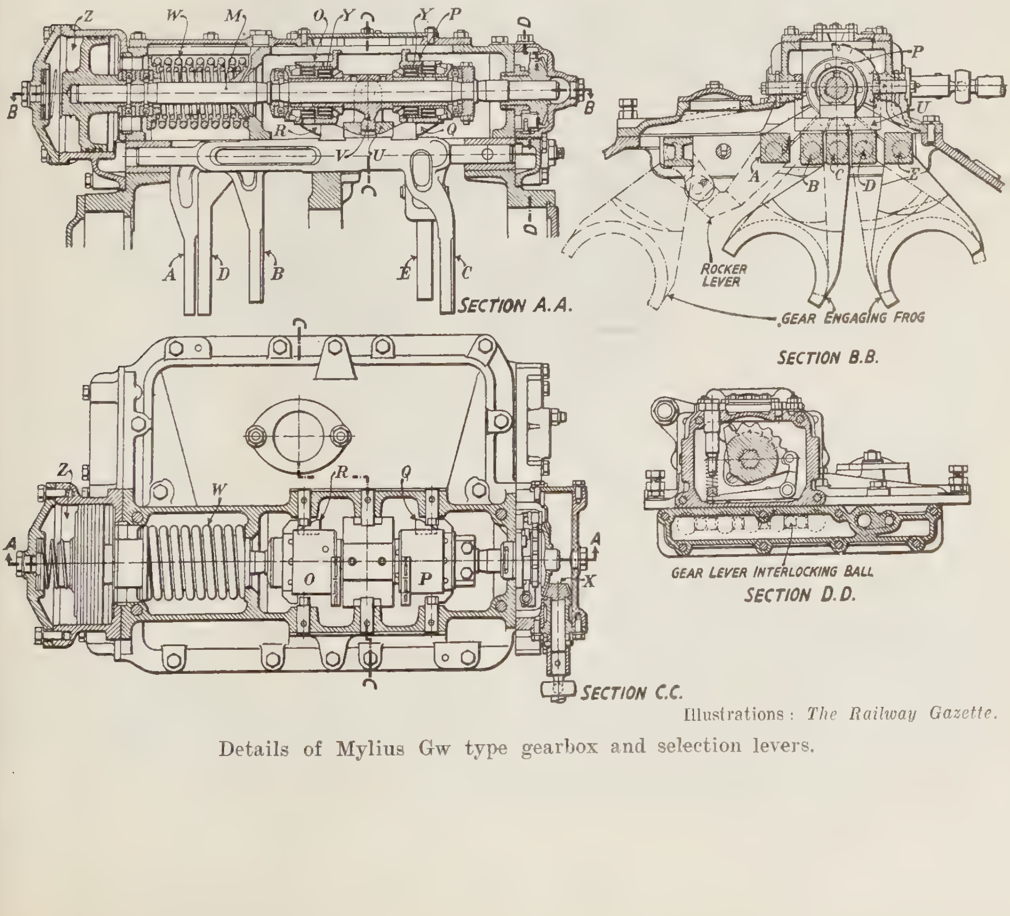
with simple controls and double-end drive for powerful railcars.

(*Diesel Railway Traction*, supplement to *The Railway Gazette*.)

Since the Mylius mechanical transmission was first applied to a petrol railcar in Holland 13 years ago it has grown steadily in popularity, until there are now about 750 sets in railway service, transmitting the torque of engines varying in output from 65 to 350 B.H.P. These Mylius drives are of various types, some being bogie-mounted, others underframe-mounted with final drives to bogie axles, and others underframe-mounted with drives to rigid axles. The latest type has been evolved for application to big railcar engines of 400 to 500 B.H.P., and in addition to the size, there is another distinctive feature in the double-way drive, allowing two axles of a bogie to be driven whether the power-transmission unit is mounted on that bogie or on the underframe or on a subframe beneath the car body. The same box can be arranged for single-end drive only if this is desired.

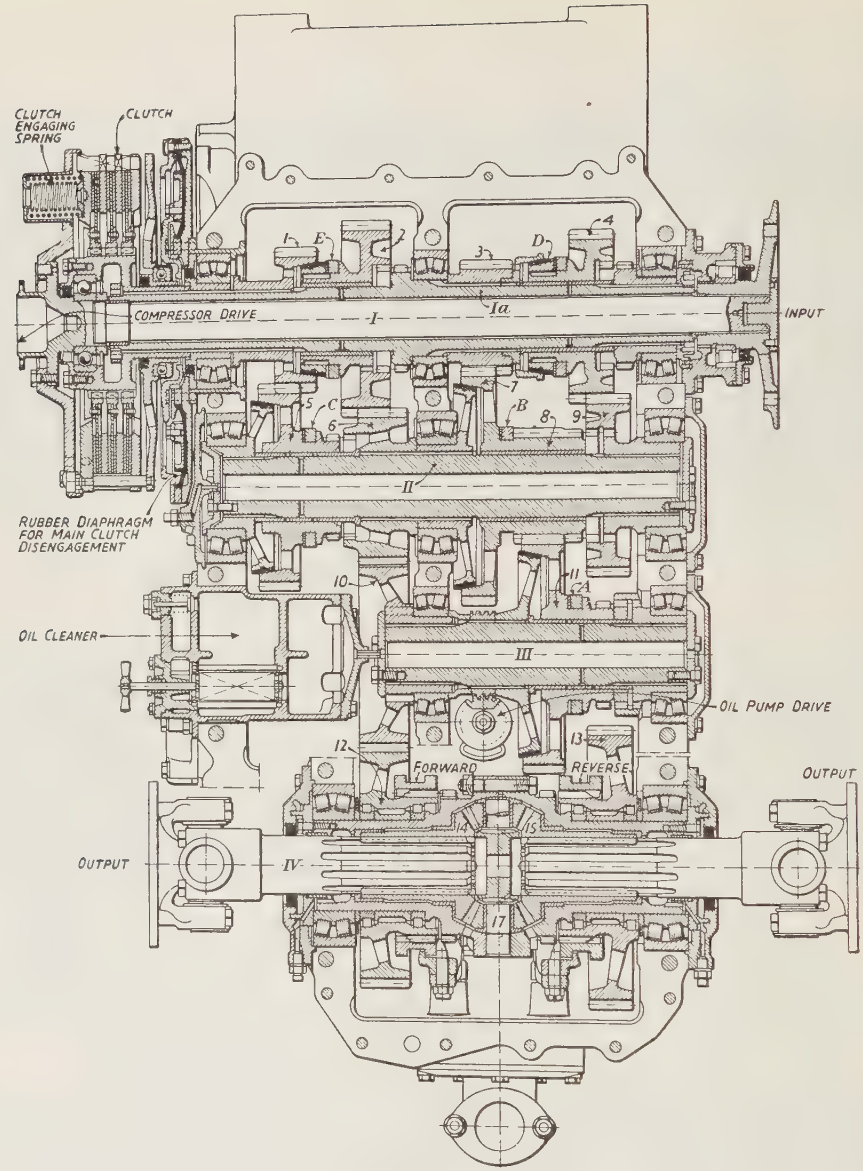
Compact design for large box.

This latest type of box, with the Mylius Gw classification, is shown in the



Illustrations: *The Railway Gazette.*

Details of Mylius Gw type gearbox and selection levers.



FORWARD GEAR.

Gear step.	Frog operated.	Wheels.
1	A	3-7 8-11-10-12
2	B	3-7-6-10-42
3	C	1-5-6-10-12
4	D	4-9-6-10-12
5	E	2-6-10-12

REVERSE GEAR.

Gear step.	Frog operated.	Wheels.
1	A	3-7-8-11-10-6-9-13
2	B	3-7-9-13
3	C	1-5-9-13
4	D	4-9-13
5	E	2-6-9-13

Sectional arrangement of the latest Mylius five-speed gearbox.

accompanying sectional drawing and, in position, in the bogie layout diagram. It is in use already in Germany and France. The main clutch is of the multi-plate pattern, and is disengaged by an air-operated rubber diaphragm; engagement is effected by eight coil spring sets provided at the outer end of the clutch. In order to ensure a more compact design, as well as easy adjustment, replacement, and inspection, the clutch is mounted close to the gearbox on the side opposite to the engine, so that a direct shaft *I* is provided through the gearbox in connecting the main clutch with the engine flywheel, and is surrounded by a hollow gear carrying shaft *Ia*.

The five-speed double-end drive gearbox has a total of four shafts, *I*, *II* and *III* being arranged in a horizontal line, and shaft *IV* being located underneath between shafts *II* and *III*. The shafts *I* and *II* carry four trains of constant-mesh gears, but only two trains are carried on each of the remaining shafts. The wheels *1*, *3*, *6*, *9* and *10* are keyed to their shafts, but wheels *2*, *4*, *5*, *8* and *11* are free to slide and are provided with a half-claw clutch on the right side and a synchronising cone clutch on the left side.

Pre-selection.

Gear changing is effected pneumatically through the medium of the cylinder *Z* fixed on the top of the gearbox. The driver pre-selects any speed desired, either mechanically by turning a handle which, by means of steel cables, actuates the pinion *X*, or, with cars running in multiple-unit, by means of electrically-controlled air cylinders fixed on the top of the gearbox. In order to effect a gear change the pinion *X* is turned and rotates the shaft *M* until the projection *R* on the loose right drum *O* opposes the face of whichever one of the gear shifting fork rods *A*, *B*, *C*, *D*, or *E* has to be actuated. This spans the spiral springs *Y* in the second drum *P*, which cannot move as the corresponding projection *Q* is pressed against the shifting rod of the gear in operation. The gear change is effected by admitting compressed air to the rubber diaphragm of the main clutch, which thus becomes disengaged, and also by actuating the piston of the cylinder *Z*, thus moving the shaft *M* to the right against the pressure of spring *W*, and disengaging by means of the finger *V* and the rocking cradle *U* the hitherto engaged gear.

By a further movement of the shaft *M* the projection *R* pulls the shifting rod of the pre-selected gear, thus engaging its cone clutch with the corresponding face on the fixed wheel and thus causing the loose wheel to run at the speed of the shaft, which now is driven from the car wheels. Meanwhile, projection *Q* on drum *P* has slid away from its obstruction and is turned by its springs *Y*, spanned when pre-selecting, so as to face the rod of the gear to be engaged. If the air is now released from cylinder *Z*, the spring *W* will pull the shaft *M* back to the left, which will at first disengage the synchronising cone clutch and then engage the claw clutch, an easy engagement of which is ensured by the fact that as the loose wheel after synchronisation gradually tends to assume a different speed, as against the fixed wheel, slipping in of both clutch members is carried out easily with an entirely shockless engagement.

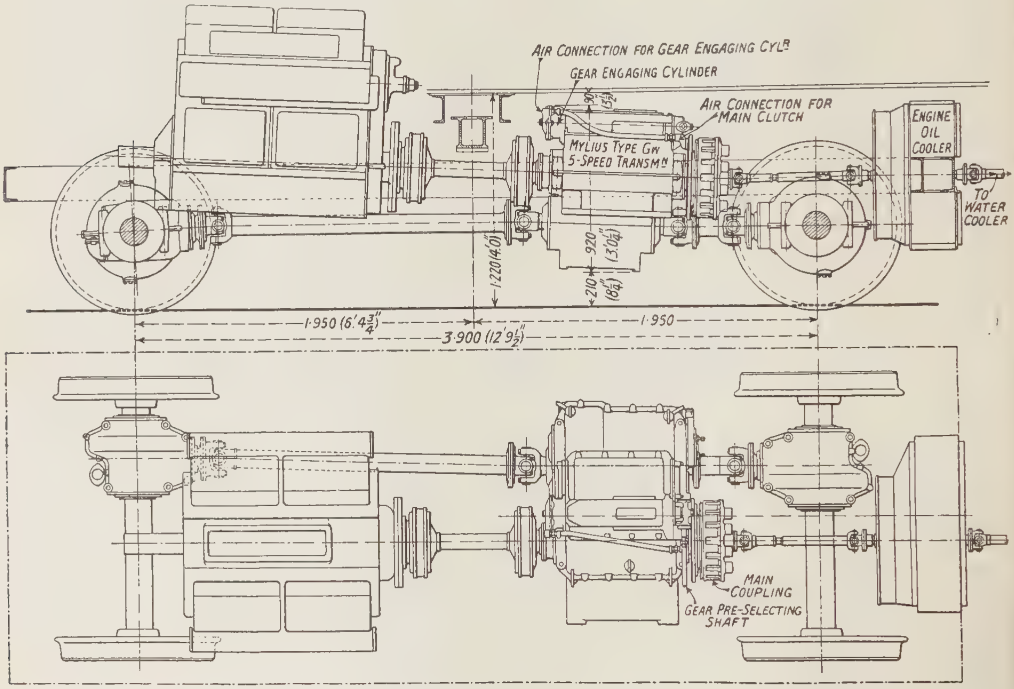
After the pre-selected gear has been engaged, the main clutch is also applied in releasing the air from the diaphragm, a very soft engagement being effected at the driver's will by the gradual release of the air pressure. This change of gears being completed, any other speed can be engaged by first pre-selecting it, and then admitting and releasing air pressure in the main clutch and operating cylinder, pre-selection of any gear being possible while the engaged gear is running.

Reversing is effected by engaging

either wheel *12* or *13* with the shaft *IV* by means of claw clutches; these clutches are pneumatically operated by a double-piston cylinder, which can be actuated only with the car at rest. The shaft *IV* is provided with a differential gear, *14* and *15*, in order to eliminate any stress which may develop due to unequal diameter of the driving wheels.

Gear losses and efficiency.

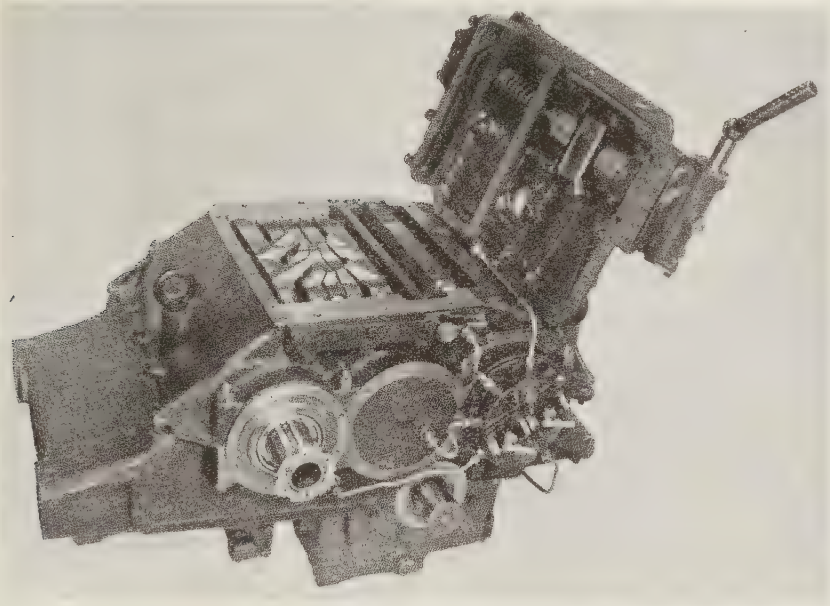
It has been found that most of the gear losses are due to squeezing oil from between the teeth for about one thousandth of a second. The gearbox is fitted with a small oil pump located inside the gearbox and driven from shaft *III;* this sprays the oil from the sump through



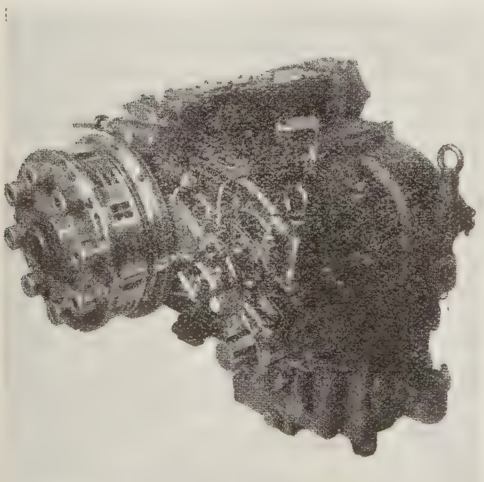
Layout of an engine and Mylius gearbox of 400 B.H.P. on a railcar bogie.

a nozzle on to the gears at the point of engagement, thus effectively reducing the so-called oil splashing losses. The loose gear wheel bearings are lubricated through the hollow shafts and two sets of removable oil cleaners are provided. The engine oil and water cooler, as well as the brake air compressor, may be driven by a shaft connected to the driving end of the main clutch. The gear ratios in the box illustrated are 4.83, 2.11, 1.92, 1.37 and 1.02 to 1 including the reversing gear, while the weight of the gearbox together with the main clutch is about 3 000 lb.

Gear changing is performed by the driver in pre-selecting the gear to be engaged by means of a centrally-located handle on the control desk, engagement being performed by a simultaneous operation of the engine throttle handle and a combined gear and main clutch operating valve, both handles being at first pulled in slowing the engine down and admitting air to clutch and gear operating cylinder, and then pushed back



350-B.H.P. Mylius five-speed gearbox with double-end drive; cover lifted back to show gear-changing rods.



Outside view of Mylius five-speed gearbox and friction-type main clutch to transmit 350 B.H.P.

to increase the engine speed and release the air. This engages both the gear selected and the main clutch, the whole operation requiring 1 1/2 to 2 seconds. The gear wheels and shafts are made of high-quality case-hardened alloy steel. The wear of the synchronising cone clutches, which when applied have only to deal with the gear to be engaged and the part of the main clutch attached to the gearbox, is very small.

A high efficiency is ensured by the simple gear design, some 4 H.P. being lost when running idle at a speed of 2 000 r.p.m., while the total efficiency of the type Gw gearbox is about 94 % in the first forward and 95 % in the first reverse speed, increasing to 97 % and 96 % with the second to fifth speed respectively; the losses at the axle drives are about 2 % of the power transmitted.

MISCELLANEOUS INFORMATION.

[621. 335 (.73) & 621. 43 (.73)]

1. — 3600-B.H.P. diesel-electric locomotives for heavy passenger service Baltimore and Ohio Railroad.

(*Diesel Railway Traction*, Supplement to *The Railway Gazette*).

The Baltimore & Ohio Railroad, which already operates on one of its subsidiary lines a 1 800-B.H.P. square-ended diesel-electric locomotive, has ordered two twin-unit streamlined locomotives of 3 600-B.H.P. from the Electro-Motive Company, and it is expected that these machines will make through runs between New York and Chicago via Washington hauling heavy passenger trains such as the Capitol Limited. The B. & O. has running powers over the Pennsylvania line between New York and Washington.

Each locomotive consists of two half units, each carried on two six-wheel bogies and each housing two 900-B.H.P. engines. The two units may be separated when required (*e.g.*, for turning), but only the front unit will be capable of use as a separate 1 800-B.H.P. locomotive for it contains all the controls, except one low-speed control system on the second unit for use during separated shunting movements. The controls lead from the driver's cab through low-voltage battery current to relay contactors in the main control panel. These main contactors are operated through electro-pneumatic switches controlled by the driver and which vary the speed of the engine and also place the traction motors either in series or parallel grouping, the last step being arranged to shunt a portion of the traction motor fields in order to increase the speed of the motors. There are eight running positions for the main engine beside the stop and idle position. All of these positions are available for either forward or backward motion.

Power equipment.

Aft of the driving control room is the engine room, occupying the entire space between truck centres. The main engines, which are mounted directly on the underframe, comprise two Winton, 12-cylinder, vee two-stroke engines, each of which is rated at 900-B.H.P at 750 r.p.m. The 8-inch by 10-inch cylinders are provided with removable liners and have separate cylinder heads and inspection plates, so that any one may be worked on separately without interfering with the others.

Each engine cooling system consists of a series of fin-tube radiators, a water circulating pump, and air circulating fans for radiator cooling. The cooling radiators are arranged in two long sections of coupled units hung parallel to the engines and supported by the underside of the roof. The water supply is taken from tanks located under the frame, which permits self-draining of the radiators during cold weather. Air is drawn into the engine room compartment through grilled openings and forced by means of large engine-driven fans through the radiators. After passing through the radiators, the air leaves through a series of vents into an exhaust manifold in the roof.

For convenience in application two 330-gall. fuel oil tanks are placed beneath the underframe. The tanks are directly connected together. The water tanks have a capacity of approximately 1 040 gall.; they are located beneath the underframe and in addition to furnishing water for the engine cooling systems, also furnish the water for the heating boiler.

Each 900-B.H.P. Winton engine drives a 700-kw. d.c. main generator through a flexible coupling. The generator voltage varies from 250 to a maximum of 750, and the field excitation is from a separate auxiliary generator mounted on the same shaft as the main generator. The field of the auxiliary gener-

ator is excited by the battery at 64 volts and the output of the main generator is varied by the variations made in the voltage output of the auxiliary generator. The main oil engines are started by applying, through switch buttons on the main control station, battery current to a special series starting winding in the field of the main generator. There is also a supplementary starting station located inside the engine room adjacent to the engine. An auxiliary diesel power plant is used to furnish current for the various auxiliaries, as well as for charging the storage batteries. The four batteries are the Exide 32-cell 450 ampere-hours type; they supply electric current for engine starting, control operation and all auxiliaries such as the fuel pumps, motors for heating boiler, and locomotive lights.

Behind the engine room the remainder of the cab is occupied by a Clarkson forced-circulation water-tube spiral-coil heating boiler and its extraneous equipment. This boiler contains six coils which rise spirally, the diameter of each spiral being less than the other so that a nest is formed in the centre where combustion occurs. The water and steam are forced from the coils into a steam separator which is a unit outside of the boiler itself. This boiler is oil fired and is designed for a safe working pressure of 255 lb. per sq. in. However, it will only be-operated at a pressure not exceeding 125 lb., the average train line pressure.

The second half unit of each locomotive has the same internal arrangement as the first with the exception that the space occupied by the driving control room on the first section is used on the second unit for a toilet and wash room for the crew. The trucks are of the six-wheel type, equipped with roller bearings, and each truck carries two traction motors, each of which is geared to a pair of wheels and supported by a spring nose suspension.

Braking apparatus is of the New York Air Brake Company's type, and the locomotives have the General Railway Signal Company's train control, the application being very similar to that followed on steam locomotives operating on the Baltimore division. The estimated weight of each half unit is 270 000 lb. (120 Engl. tons), or 540 000 lb. (240 tons) per locomotive. The adhesion weight is about 360 000 lb. (160 tons), and the tractive effort 90 000 lb. at starting and 19 200 lb. at 60 m.p.h.

* * *

On May 20th one of the new 3 600-B.H.P. diesel-electric locomotives of the Baltimore & Ohio Railroad described above made its first test run from Chicago to Washington, D. C. Pending delivery of the second power-unit of the same type, the new locomotive is hauling the streamlined Royal Blue train between New York and Washington. When the second unit is finished, the two will be transferred to work the Capitol Limited. By way of comparison, or possibly by way of an excuse, the B. & O. took its first locomotive, the *Tom Thumb* (built in 1829) out on to the line on May 25, and ran it at the head of the original directors' car to meet the new machine at a point near Washington, and together the two trains ran into Union Station.

In addition to the particulars given above the following details are of interest. All the bogie assemblies are interchangeable. Their weight is approximately 47 000 lb., and their rigid wheelbase 14 ft. 1 in. The bogie frame and swing bolster are made of cast steel, and the spring planks are of strain-relieved welded construction. The wheels themselves have a diameter of 36 inches, and are of high-carbon low-molybdenum rolled steel. They are mounted on three axles with 6-inch by 11-inch journals. The cast steel Isothermos axleboxes are fitted with a spring-cushioned lateral thrust device, and their lined bearings carry a maximum journal load of 21 600 lb.

A new theory for the treatment of load suspension has resulted in improved riding qualities and greater steadiness when rounding curves at high speed. The bogie frame is supported at four points on its equalisers by twin-group coil springs of silico-manganese

steel. The bolster is supported at each corner by a pair of chrome-vanadium elliptic springs, riding on two welded spring planks. These in their turn are carried by swing hangers pivoted from the outside of the bogie frame. Four hydraulic shock absorbers damp down lateral oscillation and ease the body load against the bogie frame when entering or leaving curves.

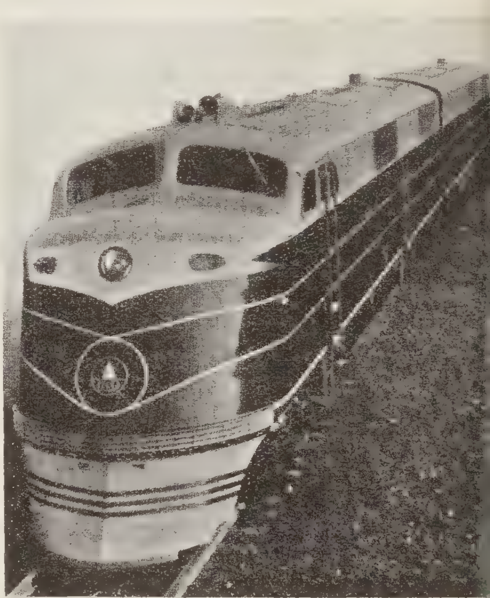
The clasp brakes have two 18-inch shoes per wheel. They are actuated by four 11-inch dia. by 10-inch stroke cylinders equipped with automatic slack adjusters. When the air pressure in each cylinder is 50 lb. per sq. in., the available retardation force approximates to 174 % of the locomotive tare weight. Both automatic and hand sanding apparatus are provided at the leading driving wheels of each truck.

Control room and equipment.

The driver is provided with an upholstered adjustable seat, and has a clear view of both sides of the approaching track through slanting windscreens of safety glass. These windows are equipped against the elements by patent wiper and hot air defroster devices. The side windows of the driving cab are of similar type, having no-draught ventilators and adjustable windows, also made in safety glass. The auxiliary driver is also provided with a comfortable seat on the left-hand side of the driving cabin, and this window is also fitted with the afore-mentioned weather defeaters.

The indicating and recording speedometer and the usual air gauges indicating brake control functions are indirectly illuminated. To the right of these instruments is situated the wheel-slip indicator, which flashes a warning red light when any set of driving wheels is slipping. Three levers only are necessary to control locomotive movements : the main throttle; reverse handle; and air brake handle. When the engines are idling and the reverse handle is in running position, any movement of the locomotive throttle is relayed electrically through four control trunk wires to each power plant of the locomotive. These telegraphic impulses are received by an electro-pneumatic mechanism which actuates the local engine-speed governor lever, thus increasing or decreasing engine speed and controlling the individual power plant output.

Situated at the head of each engine is what is known as a local control station, whence the attendant can check up the operating con-



This locomotive has eight force-ventilated nose-suspended traction motors and is fitted with supplementary separate control for each of the two hal[f] units.

dition of each power unit. Such control sta[-]tions comprise individual fuel and lubricatin[g] oil gauges, r.p.m. indicator, 12-point exhaus[t] pyrometer and an engine water thermomete[r]. Also included are the engine starting an[d] stopping buttons and an isolation switch ha[v]ing two positions, *on* and *off*. When t[he] switch handle is moved to *off*, all the electric[al] control circuits to that power plant are ope[n]ed and the engine speed reduced to idling, i[r]respective of the operation of the remaini[ng] power units. The control circuits are clos[ed] by the return of the switch to the *on* positi[on] and the engine at once responds to whatev[er] power demand is being called for by the po[si]tion of the locomotive throttle.

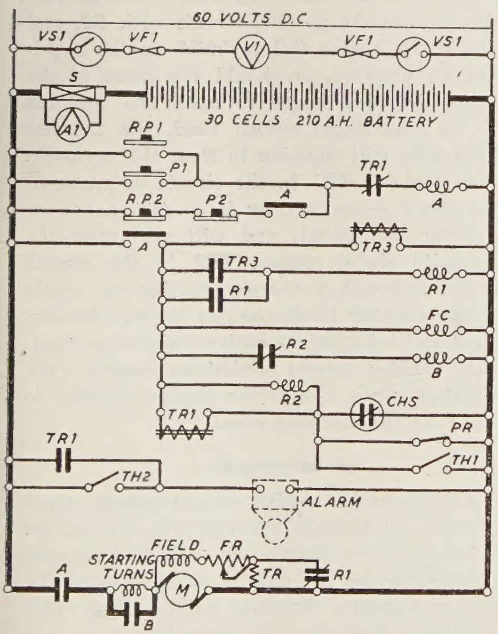
Another fitting is the trunk line alarm system, whereby abnormal engine conditions are brought to the notice of the attendant by both audible and visual means. This system includes engine-water temperature and oil-pressure switches, an 8-inch electric gong, and four illuminated enunciator signals in each locomotive unit. The enunciator boxes have three different coloured lenses indicating hot engine, low oil pressure, and heating boiler failure. The illumination of any one of these three signals causes the gong to ring, and the ringing does not cease until the failure has been located and acknowledged by the placing of the isolation switch handle in the *off* position. The gong may also be used as a call signal for the attendant by pushing a button in the operator's cab.

Feed water pumps for the train heating boiler, fire control and train line pressure regulation is entirely automatic, and adjusted by means of a single hand rheostat. The steam train line extends the full length of each locomotive unit, to provide steam for heating the operator's cab during service, and to warm the engine cooling water systems during maintenance or inspection periods. In front of the engine cab is a hood compartment, housing the 25-plate 64-volt locomotive storage battery. Access to this compartment is gained through a hinged door in the cab front partition, beneath the windscreen.

[656. 25 (.42)]

2. — Power signalling. Automatic standby plant.

(Modern Transport.)



Working diagram for the 60-volt circuit used with the Austinlite standby plant at Paddington.

We attended a demonstration at Paddington recently of a 100-kw. automatic standby plant, which has been installed for the Great Western Railway by Austinlite, Limited, of Lighthouse Works, Smethwick, Birmingham, to ensure the continued functioning of the G.W.R colour-light signalling equipment in the event of a failure of the main power supply. This equipment is of the Austinlite Company's type « B » pattern, since, in the event of mains failure, it provides an alternative source of supply following the operation of a push-button. The arrangement of the plant is, however, such that the equipment is on full load within 10 sec. of the demand being made.

The plant comprises a Paxman-Ricardo six-cylinder diesel engine supplied by Davey, Paxman and Co., Limited, Colchester, arranged to develop its rated output of 157 B.H.P. when running at a speed of 1 500 r.p.m. The engine, which is equipped with a C.A.V.-Bosch fuel pump and governor and a Burgess air cleaner, is mounted on an extended cast-iron bedplate, and is directly coupled, by means of a pin-type flexible coupling to an alternator, which was built by the Electrical Construction Co., Limited, Wolverhampton, having an output adequate for the purpose of

replacing the mains supply. To the end of the engine remote from the alternator is coupled a starting motor which is fed from a battery. The latter comprises 30 cells and has a capacity of 210 ampere-hours at the 10-hour rate. When the engine is running under its own power at the normal speed of 1 500 r.p.m., the starting motor functions as a dynamo and recharges the battery to replace the electrical energy used in bringing the set into commission. It will thus be clear that the standby plant involves the employment of two separate and distinct sources of electricity— namely, the supply from the battery at 60 volts D.C. which is used solely for the operation and control of the standby plant, and the mains supply at 460 volts, single phase, 50 cycles, which is replaced by the output of the alternator on the failure of the mains.

Supply voltage.

In the event of failure of the 460-volt mains supply, the only operation necessary to start the standby plant and thus provide an alternative source of supply, is to press one or other of the two « start » push-buttons. These are provided in duplicate, in order to give both local and remote control, there being also corresponding « stop » push-buttons at the same control points for the purpose of stopping the standby plant. The « start » push-buttons have normally open contacts and are connected in parallel, whilst the « stop » push-buttons have normally closed contacts and are connected in series. Reference to the accompanying diagram will show that the operation of either of the « start » push-buttons P1 or RP1 completes the circuit from the battery, through the normally closed contact TR1 and energises the solenoid « A », thereby closing three normally open contacts « A ». The closing of one of these contacts completes the circuit to the starting motor, another contact establishes a retaining circuit for the solenoid « A », while the third contact energises the remainder of the control equipment. The motor thus commences to crank the engine.

The functions of the various parallel control circuits are as follows : Circuit (a) through solenoid FC. The closure of the third contact « A » directly energises the fuel control solenoid FC, which thereby opens the valve and ensures that fuel is available immediately on commencement of rotation of the engine by the motor. Circuit (b) through solenoid B, and solenoid R2 in parallel with thermal relay TRI. The coil of solenoid R2 is energised immediately upon the closure of the third contact « A », provided that the contacts of the centrifugal switch CHS are closed (on account of the engine speed being below a predetermined figure), or that the contact PR of the oil pressure relay is closed. The energisation of solenoid R2 opens the normally closed contacts R2 in the circuit of solenoid « B », hence this solenoid is not energised and the starting turns are retained in the motor circuit. Simultaneously, the temperature of thermal relay TR1 commences to rise, due to the parallel circuit with R2, and should the engine fail to build up the requisite oil pressure, or should the speed of the engine be insufficient to open the contacts of the centrifugal switch CHS, the thermal relay TR1 will function to close the normally open contacts TR1 in the circuit of an audible alarm (thus causing it to give a corresponding indication), and will also open the normally closed contact TR1 in the circuit of solenoid « A », thereby causing the whole of the starting mechanism to become de-energised and bringing the entire plant to a standstill. Under normal conditions, however, the starting motor causes the engine rapidly to reach its full running speed.

Safeguards.

As soon as the engine attains normal speed (circuit (c) through solenoid R1) the starter motor ceases to function as such, and becomes a generator for the purpose of recharging the starter battery. Thermal voltage relay TR3 obtains a feed through contact « A »; the heater element of TR3 is connected across the starter battery, and is thereby subjected to its rising voltage. When thermal relay TR3 is fully actuated, and has closed its normally

open contact TR3, the solenoid R1 is energised, closing the normally open contact R1 and providing a locking circuit for its coil, at the same time removing the short circuit from part of the field resistance of the machine by opening normally contacts R1. The charge rate to the battery is therefore reduced to a trickle rate for the duration of the run, it having become fully charged as detected by TR3. Immediately the pressure in the lubrication system reaches 10 lb. per sq. in., the contacts of the oil pressure relay PR open, the solenoid R2 still being energised by the normally closed contact of the centrifugal switch CHS. When the engine attains a speed approximately 75 per cent. of the normal, the centrifugal switch CHS operates and the normally closed contact is opened, thus breaking the circuit through the solenoid R2, and resulting in the closing of the contacts R2 in the circuit of solenoid « B » and the consequent energisation of the latter. This solenoid short circuits the starting turns in the starter motor by closing the normally open contacts « B ». The order of operation of contact CHS and PR is immaterial, since solenoid « B » can only be energised if both these contacts are open. Should the engine reach its normal revolutions per minute and through inadequate lubrication or excessive overload run unduly hot, the water temperature relay TH1 will close, thereby completing the circuit through TR1 with the result that the plant will cease to operate. A room temperature relay TH2 is fitted, so that should the cooling water temperature become unduly low, rendering it likely to freeze, the circuit through TR1 is closed, and the alarm bell operated. The measuring instruments include voltmeter, kilowatt-hour meter and frequency meter, together with fuses and switchgear.